MATH PERFORMANCE ACROSS SIX MODALITY COMBINATIONS: A STUDY OF CHILDREN WITH LEARNING PROBLEMS

By

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This work is lovingly dedicated

to my family network.

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Abstract of Dissertation Presented to the Graduate Council of the University of Florida in Partial Fulfillment of the Requirements for the Degree of Doctor of Philosophy

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By

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Special educators have historically been interested in the modal preferences of students with learning problems. The primary rationale for this study was found in the equivocal findings of previous modal preference research. Previous research was found to be characterized by unreliable measures, lack of modality-pure treatments, samples of primarily non-handicapped students, reliance on a simplistic auditory/visual distinction of modal preference, and a predominance of group research designs.

The purpose of this study was to observe the relationship between the use of six different modality combinations, or performance modes (i.e., see/say, see/write, see/touch, hear/say, hear/write, and hear/touch), and the speed with which individuals

learn basic math facts. The research design was a single-subject format consisting of three phases: an assessment phase in which fluency measures were taken on a math task across all six performance mode behaviors, a treatment phase in which high and low performance modes from the assessment phase were the target of direct math instruction, and a post-treatment phase which consisted of conditions identical to the assessment phase. The subjects were four elementary-aged students with learning problems who were all performing below grade level in the area of math. The setting for all phases was the Diagnostic Classroom component of the University of Florida's Multidisciplinary Diagnostic and Training Program.

The principal findings of this study are as follows: intraindividual behavioral differences across six performance modes were found for each subject; direct instruction always increased the rate of performance, even for those performance mode behaviors found to be least proficient for each subject; increased rate of performance in the two performance modes targeted for direct instruction did not generalize to all other performance modes, and each subject made unique generalizations; when the math task presented was at frustration level for an individual, a meaningful assessment of performance mode was confounded; no consistent patterns of strengths and weaknesses were found among the subjects. These findings have implications for classroom instruction and future research in the area of performance mode.

CHAPTER I

INTRODUCTION

As a result of orderly, persistent, and creative investigation, scientists build a body of knowledge about the natural world. Science expands with the advent of observation technologies; before microscopes and telescopes, man could not focus on bacteria and quasars. Educators can use applied behavior analysis measures to focus on the functional relationships between an instructional environment and a learner's behavior. If education is approached as a science, we may piece together an understanding of the part of the natural world called learning. In the following investigation, the relationship between an individual's modal preference and rate of learning is examined using the applied behavior analysis principles of direct measurement, daily measurement, replicable teaching procedures, individual analysis, and experimental control (Lovitt, 1975). In this introductory chapter, modal preference is discussed within the framework of history of the concept, measurement of modality, research trends, and continuing questions about the utility of instruction aimed at a modal preference. The term performance mode is introduced, and the potential roles of performance mode in the design of individualized instruction and in

media research are examined. Finally, the investigation is summarized in terms of purpose, questions, design, variables, delimitations, limitations, and definition of terms.

Modal Preference

Sensory input is a basis for learning. People learn as they see, hear, touch, taste, and smell the world around them. In the school setting, students are primarily expected to learn through the visual, auditory, and kinesthetic sensory modalities (Derevensky, 1978). Given intact senses, students may not learn equally well through all modalities. The terms visual learner, auditory learner, and kinesthetic learner are used by teachers to describe students who seem to show a consistent preference or strength for learning through one of the sensory modalities. Identification of a modal preference remains a problem, yet reports of modal preferences persist as educators work to find significant factors in the learning process.

History of the Concept of Modal Preference

Early works. Educators and psychologists began conducting formal research dealing with modal preference in the latter part of the nineteenth century (Jones, 1972). In tracing the roots of modal preference research, Derevensky (1978) described an 1883 paper by Galton that reported a discrimination between visual thinking style and verbal thinking style. Bartlett (1932) studied perception and concluded that although individuals can be forced to

use a certain type of sensory cue in learning, people exhibit preferences for and will voluntarily select one modality over the others. The work of early special educators such as Montessori and Fernald mentioned modality as an important consideration when teaching children with learning problems (Barbe & Milone, 1981). In the 1940s and 1950s Strauss and Kephart, leaders in special education, also worked with the concept of modality preference (Webster, 1980), and developed teaching methods intended to accommodate a modal weakness or a modal strength.

Modal preference and learning disabilities. Persons working in the field of learning disabilities have fostered the notion that modal preference within the individual should be considered when designing instruction for exceptional students (Tarver & Dawson, 1978). Some educators suspect that learning disabled students exhibit extreme modal preferences and corresponding modal weaknesses. According to Gillingham and Stillman's (1970) view of learning disabilities, some students fail to learn to read because group teaching methods emphasize a weak modality, the visual reception mode. In contrast to the practice of remediating a weak modality, certain special educators (Johnson & Myklebust, 1967; Sabatino & Hayden, 1970; Wepman, 1967) have advocated teaching to a learning disabled child's modal strength or preference. Emphasizing a preferred modality theoretically results in more efficient learning and an improved attitude toward learning.

The concepts of modal preference and perception are closely linked, both having to do with the way humans use sensory information. Modal preference may be thought of as a part of perception, and perceptual difficulties have frequently been related to occurrences of learning disabilities. Mercer (1983) traced the history of the definition of learning disabilities and reported a 1966 work by Clements that influenced the legal definition of learning disabilities. Clements listed perceptual impairments as the second most prevalent characteristic of children with minimal brain dysfunction, a label which later evolved into the term learning disability. The first federal definition of learning disabilities used for the purpose of funding, Public Law 91-230, The Learning Disabilities Act of 1969, refers to perceptual handicaps as characteristic of learning disabled children. The 1969 definition and the current definition within Public Law 94-142, The Education for All Handicapped Children Act of 1975, both define learning disabilities as handicaps that are separate from visual, hearing, and physical impairments. Much of the work done in the area of modal preference is a result of an emphasis on perceptual problems within the field of learning disabilities.

Recent works. Individuals working in the area of psycholinguistics have typically been interested in modal preference. Recently, educators following behaviorist principles

have shown interest in the relationship between modality and behavior. Koenig and Kunzelmann (1980) encouraged teachers to consider the learning channel in which their students can perform most efficiently, with see/say, hear/write, and see/write as the most prevalent learning channels in the classroom. Haughton (1980) also advocated attention to learning channels in the precision assessment of skills.

Measurement of Modality

It is possible to quickly and accurately measure the acuity of vision and hearing, but the measurement of how we use our senses to learn proves less straightforward. Attempts to measure learners' modal strengths and deficits include norm measures, questionnaires, informal inventories, and direct measurement. Each type of assessment is subject to criticism, and no single approach has achieved general acceptance by professional educators. Arter and Jenkins (1977) questioned if many of the measures used in research have been sufficiently sensitive to detect a modal preference.

Norm measures. Koorland (1977) reported that norm measures such as the Illinois Test of Psycholinguistic Abilities, the Wepman, Frostig, Ladd, Mills, and Valett tests, are the primary tests which educators use to identify a modal preference. These psychometric instruments often fall short of the .90 reliability standard recommended by Salvia and Ysseldyke (1978) for tests used to make instructional decisions for individual students. Many

authors (Foster, Reese, Schmidt, & Ohrtman, 1976; Hammill & Larsen, 1974; Larivee, 1981; Lyon, 1977; Tarver & Dawson, 1978; Ysseldyke & Salvia, 1974) have questioned the adequacy of the reliability of norm tests designed to diagnose modal preference.

Norm measures have also been criticized in terms of the criteria employed for distinguishing a modal preference. Arter and Jenkins (1977) and Larivee (1981) observed that criteria for differentiating auditory, visual, and/or kinesthetic strengths may be arbitrary standards. Jones (1972) pointed out that tasks on the auditory and visual subtests of the Illinois Test of Psycholinguistic Abilities are not equivalent and cannot be used to compare performance across modalities. Although the results of norm tests are commonly applied in academic settings, some measures, such as the Swassing-Barbe Modality Index (Barbe & Swassing, 1979), present stimuli that do not resemble letters, numbers, or words. Application of such data to academic instruction may be a questionable practice.

Questionnaires. Instruments such as the Learning Style Inventory (Dunn, Dunn, & Price, 1977), and the Learning Modalities and Individual Differences Inventory (Papalia & Zampogna, 1977) feature a questionnaire in which learners are asked to respond to questions relating to their preferred style of learning, including modal preference. Cognitive Style Mapping, a systematic structure of learning style developed by Hill, supplements the questionnaire

format with direct observation (Mullally, 1979). Cognitive Style Mapping includes two different definitions of modal preference (Hill, 1981). First, sensory/symbol preference is considered as a set of learning variables related to auditory and visual theoretical symbols. Next, style of problem solving is defined by Hill as a modality of inference, or use of inductive and deductive approaches to problem solving. Generally, questionnaires are used to ascertain modal preference by asking learners to recall or project situations, and then identify how they usually prefer to learn.

Measurement of modal preference through a questionnaire procedure has been questioned by Davidman (1981) who stated that only high school students and adults may be able to self-report modal preference accurately. Davidman doubted that younger individuals have had sufficient exposure to different learning and teaching experiences to accurately identify a modal preference. Fischer and Fischer (1979) concurred and considered reliance on a questionnaire assessment alone to be a naive approach to identification of a preferred modality.

Informal inventories and direct observation. By nature, informal inventories and direct observation lack norms and standardization, which is objectionable to some educators (Silverston & Deichmann, 1975). An example of one informal inventory based on psycholinguistics (Meehan, 1974) features a

chart on which to record percentage of activities mastered in areas such as visual and auditory reception. In the manual for the Classroom Learning Screening assessment kit, Koenig and Kunzelmann (1980) claimed that a teacher may determine preferred learning channel by comparing the frequency of performance on see/say reading, see/write math, and hear/write spelling. Koenig and Kunzelmann's assessment strategy does not hold academic task constant, and it is questionable if a modal preference may be established in this manner. Efforts to directly observe and measure a modal preference must guard against observer bias, establish accurate descriptions of response categories, and ensure that the presence of the observer does not significantly alter the subject's behavior (Kerlinger, 1973).

Trends in Research Methodology

Kampwirth and Bates (1980) described the procedures followed in the majority of studies designed to investigate the relationship between modal preference and teaching method. The typical research procedures are as follows: sample a population of children, administer perceptual tests, divide the sample into groups on the basis of modal strengths or deficits, instruct the groups according to preferred and non-preferred modality, measure retention of material, and compare group performances. This approach has generally failed to establish an interaction between emphasis of a single modality during instruction and the groups'

modal preferences (Arter & Jenkins, 1977; Austin & Donovan, 1978b; Derevensky, 1978; Jones, 1971; Kampwirth & Bates, 1980; Larivee, 1981; Miller, 1979; Newcomer & Goodman, 1975; Tarver & Dawson, 1978).

In light of current modality research results, Gredler (1978) stated that we may only conclude that modality-based instruction is not appropriate for the group. Gredler pointed out that the data do not preclude the possibility that modal preference may still be important for certain individuals. Lumpkin (1971) reported researchers' impressions that individuals do differ in terms of modal preferences. Derevensky (1978) summarized that "many research studies have failed to investigate individual differences in modality preferences as well as neglecting essential intra-individual differences" (p. 9).

Examples of single subject research designed to investigate the relationship between modal preference and modality-based instruction are lacking within professional educational literature. Several authors (Daniel & Tacker, 1974; Derevensky, 1978; Gredler, 1978; Lilly & Kelleher, 1973; Lumpkin, 1971; Mills, 1956; Patridge, 1976) mentioned individual modal preference patterns and individually designed instruction as potentially important for some learners. The dominance of group designs within modality research (Patridge, 1976) and the inconclusiveness of such research, may point to a need for alternative research designs that are more sensitive to intraindividual differences in performance.

Continuing Questions

Discarding the concept of a relationship between a learner's preference and the mode of instruction may be premature. Educators have called for new and different approaches to modality research (Barbe & Milone, 1981; Fischer & Fischer, 1979; Foster, Reese, Schmidt, & Ohrtman, 1976; Newcomer & Goodman, 1975; Silverston & Deichmann, 1975). The responses of 340 special education teachers surveyed by Arter and Jenkins (1977) indicated that 87% of the teachers were familiar with the modality model, and of those who were aware of the model, 99% agreed that modality should be a major consideration in planning instruction for special education students. When Chandler (1981) asked teachers of learning disabled students what topics they wanted researched, the third most prevalent response was learning modality. To date, research has not provided educators with definitive information about how the individual learner's modal preference influences learning.

Performance Mode

Performance Mode Defined

Every academic task required of students in the classroom may be described in terms of a performance mode. Taking a spelling test usually involves the hear/write performance mode; reading aloud is described as see/say; entering an answer during a computerized drill program may require the student to work in the

see/touch performance mode in which the student receives visual input and is required to touch a key as a response. The combination of input modality/output modality used to perform a task is defined as a performance mode. Performance modes are present throughout the teaching process. Instructional materials, standardized achievement tests, and teachers' lesson plans all feature different uses of input and output modality combinations, but generally the combinations are not systematically selected or manipulated. If some students do have distinct modal preferences, then performance mode may be an important factor to control in the design of individualized instruction.

Performance Mode and Individualized Instruction

Individualized instruction is currently the goal of many teachers, schools, and educational programs. In the area of special education, individualized instruction is a legal mandate of Public Law 94-142, The Education for All Handicapped Children Act of 1975. Appropriate instruction for each student depends on content selection and method selection on an individual basis (Barclay, 1981; Davidman, 1981; Dunn, Dunn, & Price, 1977; Gregorc, 1979; Hunt, 1981; Hunter, 1979). Presently, the teacher may determine appropriate content through the use of diagnostic criterion-referenced, and/or norm-referenced achievement tests, but teachers lack assessment strategies which provide reliable information about how best to teach each student

(Salvia & Ysseldyke, 1981). One approach to the assessment of how an individual learns has been to examine the learner's use of sensory modalities during instruction. If modal preferences can be assessed in a valid and reliable manner, and if performance mode is important for some learners, then teachers may be trained to incorporate use of appropriate performance mode into individualized instructional plans for their students.

Performance Mode and Media Research

An important consideration within an individualized instructional design is selection of educational media. Under the specifications of Public Law 94-142, every child receiving special education services must have an Individualized Educational Program (IEP), which may require specification of instructional materials. Hickman and Anderson (1979) and Weiderholt and McNutt (1977) reported a lack of research in the area of materials selection for exceptional students. Media specialists (Clark, 1974; Jonassen, 1979; Salomon, 1978) see a need for media research that emphasizes the prediction of learner outcomes based on the interaction of specific learner and media attributes. Research of this type could be directly applied to individualizing classroom instruction if the dependent variables involve academic tasks and the independent variables may be manipulated in the classroom setting.

Some models for media selection mention individual learner characteristics as a point of consideration within a systematic

selection of instructional materials (Cohen, Alberto & Troutman, 1979; Cornbleth, 1981; Diamond, 1977; Goodman, 1971; Gorman & Wilson, 1978; Gropper, 1976). Although the authors of these models recognize the individual and sometimes mention traits to be considered, little guidance is given for practical decisions concerning use of educational media within individualized instruction. Educational media and instructional materials feature different performance modes in which learners are required to practice and demonstrate skills. If modal preference is an important variable in learner performance, then the performance modes featured in instructional materials may be an important consideration in the process of media selection for individualized instruction. Further research is needed to establish the utility of this approach to media selection.

Purpose

The purpose of this study was to observe the relationship between performance mode and the speed with which individuals learned basic math facts. In response to shortcomings in previous modal preference research, this investigation used a direct assessment of an academic task across performance modes (viz., see/say, see/write, see/touch, hear/say, hear/write, and hear/touch). Each subject received a separate assessment, treatment, and analysis, all conducted with procedures that could be used in the special education classroom. The aim of the

investigation was to collect data pertaining to performance mode that could be helpful in the design of individualized instruction.

Questions

The experimental questions were as follows:

1. Do the performances of each subject show intraindividual differences in celeration values after a direct assessment of a math task across six performance modes?

2. What are the effects on celerations of math performances when direct instruction is provided in the performance modes identified as high and low during the assessment phase?

3. How does rate of performance in the six performance modes compare for measures taken before and after direct instruction in two of the performance modes for each subject?

4. What is the discrepancy between high and low celeration values for both the assessment and treatment phases for each subject?

5. Are there any patterns of performance among the subjects in terms of performance mode for the assessment, treatment, and post-treatment phases?

Design

The research design was a single subject investigation with three phases: (A) a multi-element assessment phase involving six different performance mode conditions, (B) a treatment phase with a multiple baseline across two instructional conditions featuring the

performance modes with the highest and lowest celeration values from the assessment phase, and (A') a post-treatment phase during which instruction was removed and the six performance mode conditions were presented again. Content (mathematics), task (basic facts in one of the four operations), instructor, feedback, reinforcement, instructional setting, and time of experimental session were constants for each of four subjects.

Variables

The independent variable in this study was performance mode featured in assessment, treatment, and post-treatment phases. The six performance modes selected for this investigation were as follows: see/say, see/write, see/touch, hear/say, hear/write, and hear/touch. The dependent variable was the celeration of performance for each phase and performance mode condition. Celeration notes the change (decrease or increase) in frequency per unit of time. Celeration values are calculated using rate of responses per minute across several days, and celeration lines may be drawn on a graph to depict trends in the data.

Delimitations

The research activity was an examination of the math performances of four subjects using an A-B-A' single subject research design. The subjects were elementary-aged students who were referred for complex learning, behavior, and/or medical problems to the University of Florida Multidisciplinary Diagnostic

and Training Program, and were subsequently assigned to the Diagnostic Classroom. The subjects selected were the four children who entered the classroom after the research proposal was approved, providing the student was referred for learning problems, and the student was performing below his or her grade level on math tasks. A single instructor from the Diagnostic Classroom staff conducted the initial assessment, delivered the instruction, and recorded all measures. An individual assessment conducted prior to entry in the Diagnostic Classroom was used to define a set of basic math facts at an instructional level for each subject. All phases of the study controlled presentation of math facts in terms of specific subsets of facts and the performance modes used for modeling, practice, and measurement. Each session was conducted in a uniform manner with the instructor following detailed scripts for each phase of the experiment.

Limitations

Experimental research is always subject to confounding variables from uncontrolled sources, and this study was subject to certain limitations. During all three phases of the experiment, powerful variables other than performance mode may have influenced behavior. The subject generalizations possible as a result of this research will be limited to elementary-aged children experiencing learning problems in the area of mathematics. In addition, the results may only be generalized to the specific content area of

basic math facts. Replications of the study with different content areas and different populations could extend the generalizability of the results. The interpretation of modal preference was limited to the performance mode condition under which the learner performed most efficiently, as measured by celeration of performance on a task involving basic math facts.

In this investigation, the math task itself was consistently presented to the subjects in either spoken or written numerical symbols, and the subjects were expected to respond with either spoken or written numerical symbols. The work of Cawley (1977) suggested that students with learning problems may need to acquire math concepts in a systematic progression of activities prior to working with symbols. Cawley described a series of four types of activities through which instruction may be delivered and learning demonstrated: construct (arrange two- or three-dimensional manipulatives), present (display two- or three-dimensional manipulatives in fixed representations of math operations), identify (mark or point to a non-symbolic choice among several options), and state and graphically symbolize (make a drawing, speak numbers, or write numbers). Given Cawley's perspective, students required to work at the symbolic level may not have the appropriate understanding of the calculations, and may need instructional activities that involve construction, presentation, and/or identification.

Applied Behavior Analysis

Applied Behavior Analysis (ABA) is a scientific approach to measurement of behavior. Generally used in single subject research, ABA procedures include direct measurement of observable behaviors, continuous (usually daily) measures taken over time, replicable procedures, examination of functional relationships between subject and environment, and experimental control over events prior to, during, and after the target behavior occurs. ABA data analysis is done at the level of the individual, with replications across other subjects and/or settings required to establish a principle of behavior. Researchers using ABA methods tend to avoid research designs involving large groups and statistical manipulation of summary data.

Celeration

Celeration is a measure noting degree of change, either increasing or decreasing, in frequency of behavior (White & Haring, 1980). Celeration summarizes trends in day-to-day frequency measures of behavior and may display trend summary data as a straight line on a chart or as a numeric value. Change from low rates to high rates is represented by an ascending line on a chart, or a number preceded by a multiplication sign (x1.24). Change from high rates to low rates is shown as a descending line on a chart, or a number preceded by a division

sign (±2.01). Deceleration can be desirable if the trend appears in rate of errors or in rate of inappropriate behaviors.

Direct Instruction

The systematic training of skills may be referred to as direct instruction. One emphasis of direct instruction is the learner's observable response to stimuli. Mercer (1983) and Stephens, Hartman, and Lucas (1978) contrasted direct instruction, or skill training, to ability training that emphasizes unseen processes such as visual perception. The phrase "direct instruction" is used within this study to underscore the observable nature of performance mode.

Educational Media

Instructional materials used with learners may also be called educational media. Gerlach and Ely (1980) classified educational media in the following eight categories: real things, printed words, graphic representations, still pictures, motion pictures, audio recordings, programs (computer-based and other programmed instruction), and simulations. Educational media may be commercially published materials or teacher-made materials.

Individualized Instruction

Individualized instruction consists of teaching procedures appropriate for each student's current level of academic achievement and learning style. Although one-on-one instruction may be a component of individualized instruction, teachers can

design group instruction that meets the needs of very different individuals simultaneously. Individualized instruction often includes a test-teach-test cycle in which teachers first assess academic performance and/or learning style, then provide appropriate instruction, and finally test for mastery.

Kinesthetic

The kinesthetic modality is associated with the sense of touch. Some definitions of kinesthetic sensation include the element of movement in addition to tactile input. Writing is often considered to be a kinesthetic activity.

Modal Preference

The aptitude or preference some learners demonstrate for learning through one of the senses in comparison to the other senses is referred to as a modal preference. In the classroom setting the visual, auditory, and kinesthetic modalities are the primary modes through which learners are expected to assimilate information. A modal preference may be due to an obvious deficit in the acuity of one or more senses (e.g., a hearing impairment), or the modal preference may be of unknown origin and occur in persons whose senses are intact.

Performance Mode

Performance mode is a description of behavior in terms of the combination of input modality/output modality used to perform a task, especially an academic task. For example, see/write is a prevalent performance mode in the classroom in which students

receive input visually from a worksheet or a blackboard and are expected to make a written response. Every academic task required of students may be described in terms of its performance mode.

Summary

The theory of modal preference persists throughout the history of the field of learning disabilities. Researchers have expressed a need for reliable and valid assessment of modal preference, and a need for investigations that examine the interaction between modality-based instruction and individual learners. Teachers in daily contact with children experiencing academic problems continue to consider modal preference as an important variable in the learning process. This study featured direct assessment of performance on a math task across six performance modes, placement of subjects in two treatment conditions featuring instruction in the highest and lowest performance modes, and measurement of performance in the original six performance mode conditions after instruction was withdrawn.

CHAPTER II

REVIEW OF RELATED LITERATURE

The inadequacies of previous modal preference research provide a rationale for this study. Chapter II is a summary and critique of existing research involving modal preference and academic learning. This chapter contains the inclusion criteria for research reviewed, description and analysis of research studies in terms of design, subjects, measures, treatments, and results, and a summary of the findings of several reviews of modality research. Finally, the results of one study which does not meet inclusion criteria, but does reveal pertinent information about math performance and input/output modality combinations, will be reviewed.

Inclusion Criteria

The following points were used to select data-based research reports for this review of the literature:

1. Experimental question(s) dealing with the effect of instruction matched to modal preference or strength,

2. Dependent variable(s) which may be classified as academic behaviors,

3. School-aged subjects (kindergarten through the twelfth grade),

4. Publication date of 1970 or later,

5. Availability of a complete research report including descriptions of subjects, procedures, and results.

The following sources were used in the search for appropriate publications: card catalogs at the University of Florida libraries, Current Index of Journals in Education, Educational Resources Information Center, Exceptional Child Education Abstracts, Resources in Education, and the reference sections of related articles, chapters, and books. The search resulted in 18 research reports that met the above criteria (see Table 1).

Research Characteristics and Results

Research Design

Group design. Of the 18 investigations included in this review, 17 studies used a group research design to study the effectiveness of matching modal preference to instruction emphasizing one modality. The simplest research design involved two groups, an auditory preference group and a visual preference group, as established by testing designed to discriminate modal preferences (Bruininks, 1970; Foster, Reese, Schmidt, & Ohrtman, 1976; Gallistel, Curran, & Hawthorne, 1973; Lilly & Kelleher, 1973; Miller, 1974; Waugh, 1973). Some researchers expanded on the two-group approach by addition of a control group (Austin & Donovan, 1978a; Smith 1971; Sabatino, Ysseldyke, & Woolston, 1973), or by inclusion of a no-preference group (Bursuck, 1971; Daniel & Tacker,

Table 1

Summary of Modal Preference Research

Study	Subjects	Modality measures	Dependent measures	Treatments	Criticisms
		Significant results			
Austin & Donovan, 1978a	107 1st graders, regular classes	6,9,10, 11,12, 18,28	2,10	phonics and sight word reading	No control for teacher competence; measurement of modality
Bursuck, 1971	132 10th graders with reading problems	22	1	reading, listening and reading	Inadequate description of procedures; measurement of modality
Daniel & Tacker, 1974	45 regular class subjects, 7.5-8.5 yrs. old	5,10	11	listening, reading	Generalized results beyond population studies; measurement of modality
Foster et al., 1976	20 elementary-aged subjects	16,24	12	phonics, sight word reading	Measurement of modality
Lilly & Kelleher, 1973	57 educationally handicapped, 8-12 yrs. old	15	6	listening, silent reading	Measurement of modality
Wepman & Morency, 1975	235 1st-3rd graders, regular classes	11	2,4	Ginn basals, auditory and visual techniques	Treatments not modality-pure; dependent measures do not match treatment content

(table continues)

Table 1--continued

Study	Subjects	Modality measures	Dependent measures	Treatments	Criticisms
		Non-significant results			
Bruininks, 1970	105 2nd and 3rd graders, black males, low SES	1,4,10, 14,19,20, 21,27,28	12	phonics and sight word reading	Subjects involved in 2 yr. phonics program prior to treatment of single 23-minute sessions; measurement
Gallistel et al., 1973	58 1st graders, reading problems	8,10,20, 27	9	phonics and sight word reading	Measurement of modality and the dependent variable
Harter, 1981	6 3rd graders in special education resource room	23	7,8	listening, reading, tracing words	Measurement of modality; weak experimental design; lack of experimental control
Miller, 1974	62 1st graders, regular class	5,10,11, 13,26,28	2	phonics and sight word reading	Measurement of modality
Newcomer & Goodman, 1975	57 4th graders, regular classes	10	12	listening, reading	Measurement of modality; single session treatment
Ringler & Smith, 1973	106 1st graders, low SES	17	4	listening, reading, tactile	Conventional reading instruction continued during experiment; measurement of modality

(table continues)

Table--1 continued

Study	Subjects	Modality measures	Dependent measures	Treatments	Crticisms
Robinson,1972	448 1st graders regular classes	7,28	3,4,12	Ginn and Scott-Foresman basals, Hay Wingo	Treatments not modality-pure; measurement of modality
Sabatino & Dorfman, 1974	90 EMR students, mean age 9.8 yrs.	2,24	5	Auditory and visual discrimination training	Treatment content not related to dependent measure; measurement of modality
Sabatino et al., 1973	72 EMR students, 13-14 yrs. old	3,24	2,9	Sullivan Programmed Readers, DISTAR	Treatments not modality-pure; measurement of modality; dependent measure not related to treatment
Smith, 1971	72 1st and 2nd graders, disadvantaged	10	4	I.T.A., Reading with Phonics, Words in Color	Treatments not modality-pure; measurement of modality
Vandever & Neville, 1974	282 2nd graders, regular classes	11	12	phonics, sight word, tracing	Assignment to groups based on predictions of performance from regression analysis

(table continues)

Table 1--continued

Study	Subjects	Modality measures	Dependent measures	Treatments	Criticisms
Waugh, 1973	166 2nd graders, Title I program	10	11	phonics and sight word reading	Measurement of modality

Note. Refer to Table 2 for key to modality measures and refer to Table 3 for key to dependent measures.

1974; Sabatino & Dorfman, 1974; Wepman & Morency, 1975). Two studies (Ringler & Smith, 1973; Vandever & Neville, 1974) included a group described as having a preference for the kinesthetic modality. The remainder of the group designs (Newcomer & Goodman, 1975; Robinson, 1972) featured a combination of high and low modal preferences. The size of groups studied ranged from 20 (Foster et al., 1976) to 448 subjects (Robinson, 1972).

Single subject design. Of the 18 publications selected for this review, only one (Harter, 1981) was found to use a single subject approach to answering the question of effectiveness of modality-based instruction. Harter designed an investigation in which spelling test scores during six weeks of "normal" spelling instruction were compared to six weeks of modality-based instruction. This may be described as an A-B design, with Phase A conditions as the baseline of normal instruction, and Phase B as the experimental condition consisting of modality-based instruction. Essentially, Harter's research involved an administration of the Swassing-Barbe Modality Index, and provision of six weeks of individualized spelling instruction emphasizing each student's identified modal preference.

Critique of designs. Lack of experimental control is a shortcoming of several research designs. Austin and Donovan (1978a) pointed out that they failed to control for teacher competence, as measured by the investigators' ratings on an unspecified scale. If

the teachers in Austin and Donovan's research did vary according to teacher competence, then that variation is potentially more powerful than modality of instruction. Tarver and Dawson (1978) criticized Bruininks' study because the subjects were previously involved in a two-year program emphasizing phonics, and the experimental treatment consisted of single 23 minute lessons using phonetic and sight word approaches to decoding words. Vandever and Neville (1974) reported difficulty in ensuring that students used designated cues for the visual and auditory experimental conditions. Harter's (1981) work considered individual performances in a resource classroom setting, but the research lacked controls over several potentially confounding variables, including instruction in the regular classroom. Harter used an A-B research design which is not sufficiently complex to control for the effects of simultaneous, uncontrolled events (Hersen & Barlow, 1976).

Although many introductions to the research reports referred to diagnostic-prescriptive teaching and individualized instruction, the majority of research designs involved groups of learners receiving identical instruction. Group designs may provide information as to the utility of modality-based instruction on a group basis only. Conclusions based on research with groups are not always applicable to the individual learner (Johnston & Pennypacker, 1980). Special educators who primarily deliver individualized instruction need research designed for application

to the individual learner in order to determine if modality-based instruction is a worthwhile endeavor.

Characteristics of Subjects

Grade level. The most popular subjects for investigations dealing with modality-based instruction were first graders (N=868, or 41% of all subjects). In part, this may be due to the interest in phonetic and sight word approaches to beginning reading, which were frequently classified as auditory and visual experimental treatments. Elementary-aged children in grades one through six made up 90% (N=1916) of all subjects selected for the 18 research efforts. Only two studies (Bursuck, 1971; Sabatino, Ysseldyke, & Woolston, 1973) selected subjects not in elementary school (N=204, or 10% of all subjects).

School program. Pupils in regular education programs were studied far more frequently than any other school population (N=1539, or 73% of all subjects). Included within the group of regular education students were 285 children from disadvantaged or low socio-economic backgrounds (Austin & Donovan, 1978a; Ringler & Smith, 1973; Smith, 1971). Eleven percent of the total number of subjects (N=225) were special education students, which did not include students classified as disadvantaged, but did include students in a resource room (Harter, 1981), educationally handicapped students (Lilly & Kelleher, 1973), and educable mentally retarded students (Sabatino & Dorfman, 1974; Sabatino,

Ysseldyke, & Woolston, 1973). Waugh (1973) selected 166 students (7% of the total subjects) from a Title I program. Bursuck (1971) and Gallistel, Curran, and Hawthorne (1973) chose non-special education students with reading problems (N=190, or 9% of all subjects).

Critique. Modality-based instruction has been emphasized as an approach to teaching special education students (Newcomer & Goodman, 1975), yet researchers have primarily selected regular education students as subjects. Of the eight research reports published in Exceptional Children, Journal of Learning Disabilities, and Journal of Special Education, only two studies involved handicapped subjects (Lilly & Kelleher, 1973; Sabatino & Dorfman, 1974). Daniel and Tacker (1974) studied a population of regular education students, yet they concluded that their results may be applied to children with learning problems. Daniel and Tacker's generalization of their results to handicapped populations was inappropriate.

The distribution of subjects across grade levels revealed some groups that have not been included in learning modality research, based on the sample of studies included in this discussion. None of the studies included kindergarteners, who may be a very good population to study due to their lack of exposure to a variety of teaching methods. At the other end of the school system, secondary students have not received much attention in modal preference

research. If it is indeed true that the older students become, the less pronounced modal preferences become (Barbe & Milone, 1981; Derevensky, 1978), then secondary students with pronounced modal preferences may have a special need for instruction designed to accommodate a modal preference. Finally, despite the frequency with which first graders have been studied, all of the studies with first graders as subjects were concerned with beginning reading instruction. Study in other academic areas may prove beneficial.

Measurement

Measures of modal preference. Because each study included in this review was concerned with the interaction between learners' modal preferences and modality of instruction, all subjects were first tested to determine a modal strength or deficit. Within the 18 research reports, 27 different standardized instruments and a variety of informal inventories were employed to test modal preference (see Table 2). Twenty-one measures appeared only one time across all studies. The most frequently used measures were the Illinois Test of Psycholinguistic Abilities (eight times), Wepman Auditory Discrimination Test (four times), Test of Auditory Perception (three times), Primary Mental Abilities (two times), Wechsler Intelligence Scales for Children (two times), and Detroit Test of Learning Aptitudes (two times). Ten investigations used batteries of tests and determined auditory and visual strengths using scores from different instruments.

Table 2

Modality Measures and Frequency of Use in Studies from Table 1

Reference number	Modality measure	Frequency of use
1	Auditory Attention Span for Related Syllables	1
2	Beery-Bukenica Developmental Test of Visual-Motor Integration	1
3	Bender Visual-Motor Gestalt Test	1
4	Children's Embedded Figures Test	1
5	Detroit Test of Learning Aptitude	2
6	Developmental Test of Motor Integration	1
7	Goins Visual-Perceptual Tests	1
8	Goldman-Fristoe-Woodcock Test of Auditory Perception	1
9	Goodenough Draw-A-Man Test	1
10	Illinois Test of Psycholinguistic Abilities	8
11	Informal inventory	3
12	Keystone Visual Survey Tests	1
13	Lee Clark Reading Readiness Test	1
14	Memory-for-Designs	1
15	Mills Learning Methods Test (adaptation)	1
16	Multiple-Choice Bender Visual-Motor Gestalt Test	1

(table continues)

Table 2--continued

Reference number	Modality measure	Frequency of use
17	New York University Learning Modalities Test	1
18	Peabody Picture Vocabulary Test	1
19	Perceptual Integration Tests	1
20	Primary Mental Abilities Test	2
21	Roswell-Chall Auditory Blending Test	1
22	Sequential Test of Educational Progress	1
23	Swassing-Barbe Modality Index	1
24	Test of Auditory Perception	3
25	Visual Automatic Test	1
26	Visual Closure, Threshold of Visual Closure	1
27	Wechsler Intelligence Scales for Children	2
28	Wepman Auditory Discrimination Test	4

Dependent measures. In 17 of the 18 studies, the dependent measures involved some form of reading performance. Informal measures of word recognition constituted the largest group of dependent measures and were used in five studies. The Gates-MacGinitie Reading Test and the Metropolitan Reading Test were both used in four studies. Word recall, which was operationally defined both as writing words from memory and as selecting key words embedded in a list, was used as the dependent measure in two investigations. A total of ten different reading measures and three spelling measures were used to quantify the dependent variables of reading and spelling performance (see Table 3).

Critique. The most prevalent criticism of modal preference research concerned measurement of modalities (Arter & Jenkins, 1977; Austin & Donovan, 1978b; Derevensky, 1978; Jones, 1971; Lilly & Kelleher, 1973; Newcomer & Goodman, 1975; Patridge, 1976; Sabatino & Dorfman, 1974; Sabatino, Ysseldyke, & Woolston, 1973; Silverston & Deichmann, 1975; Tarver & Dawson, 1978). Standardized instruments were criticized because of relatively low reliabilities. For example, Lilly and Kelleher reported that the most popular standardized instrument, the Illinois Test of Psycholinguistic Abilities, has reliability coefficients for 6 of 10 subtests that range below a .50. A relatively new instrument used in Harter's (1981) research, the Swassing-Barbe Modality Index, has a

Table 3

Dependent Measures and Frequency of Use in Studies from Table 1

Reference number	Dependent measure	Frequency of use
1	California Reading Tests	1
2	Gates-MacGinitie Reading Tests	4
3	Gray Oral Reading Test	1
4	Metropolitan Reading Test	4
5	Peabody Individual Achievement Test	1
6	Recall of facts from text	1
7	Spelling daily practice scores	1
8	Spelling weekly test scores	1
9	Wide Range Achievement Test	2
10	Woodcock Reading Mastery Tests	1
11	Word recall (informal)	2
12	Word recognition (informal)	5

test-retest reliability value of .58, which falls short of the .90 standard recommended for tests used to make instructional decisions for individual students (Salvia & Ysseldyke, 1978).

Reliability is not the only issue with tests of modal preference. The discreteness of aptitude differences was questioned by Austin and Donovan (1978b). Smith (1971) maintained that the categories of auditory and visual learners may be artificial and simplistic. Larivee (1981) and Miller (1979) considered criteria used to classify subjects for experimental modality groups as arbitrary. Even if a single instrument was used to assess modal preference, Derevensky (1978) pointed out that subtests do not always present equivalent tasks in the different modalities, and such results may not be comparable.

None of the research efforts used either the questionnaire format or applied behavioral analysis measurement procedures. Several authors did suggest alternatives that may improve the measurement of modal preference. Sabatino and Dorfman (1974) suggested continuous measurement on criterion-referenced tests as an alternative to using normed instruments with questionable reliabilities. Tarver and Dawson (1978) mentioned rate of learning as a potentially important measurement strategy for researchers.

Although the dependent measures found in the 18 studies did match the dependent variable in terms of academic area, they frequently required the learner to perform in a manner incongruous

with the identified modal preference. For example, Daniel and Tacker (1974) assessed word recall in a think/write format for all subjects, including those identified as having an auditory preference. Standardized dependent measures may relate only indirectly to content covered in the treatment condition, and thus may not be sensitive to achievement resulting from the experimental instruction. Ideally, dependent measures involve precisely the content covered in direct instruction and assess the learner in a mode congruent with the established modal preference. This set of circumstances was not found in any of the studies reviewed.

Treatment

Commercial reading programs. Five investigations (Austin & Donovan, 1978a; Robinson, 1972; Sabatino & Dorfman, 1974; Smith, 1971; Wepman & Morency, 1975) designated commercial reading programs to auditory and visual treatment conditions. Wepman and Morency used the Ginn series for both conditions and made adaptations in media and teacher presentations which emphasized auditory or visual modalities. Commercial programs classified as primarily auditory included Structural Reading Program, Hay Wingo materials, DISTAR, Initial Teaching Alphabet, and Reading with Phonics. The commercial programs that researchers classified as primarily visual in nature included Words in Color, Sullivan Programmed Reading Series, Ginn basal series, Scott-Foresman basal series, and Hawaii English Program.

Phonetic and sight word approaches. Frequently researchers investigating a modality by treatment interaction defined reading with phonics as an auditory treatment and reading with sight words as a visual treatment (Bruininks, 1970; Foster, Reese, Schmidt, & Ohrtman, 1976; Gallistel, Curran, & Hawthorne, 1973; Miller, 1974; Vandever & Neville, 1974; Waugh, 1973). Phonics may be defined as decoding through the use of sound/symbol associations, and the sight word approach may be defined as decoding through recognition of a whole word. In addition to treatment conditions involving phonics and sight word instruction, Vandever and Neville included a kinesthetic treatment condition which consisted of tracing the words on which subjects were later tested for word recognition.

Listening and reading. Six studies differentiated treatments in terms of listening and reading text or words in a list (Bursuck, 1971; Daniel & Tacker, 1974; Harter, 1981; Lilly & Kelleher, 1973; Newcomer & Goodman, 1975; Ringler & Smith, 1973). The listening conditions frequently made use of tape recordings, and the visual conditions generally included projection of an image of the word or text through use of a slide or an overhead projector. Two studies in this group featured the kinesthetic modality: Harter assigned students to practice spelling words by tracing them on a blackboard, and Ringler and Smith taught word recognition by requiring subjects to use their fingers and trace pipe cleaners attached to index cards in the form of words.

Discrimination training. Sabatino, Ysseldyke, and Woolston (1973) created the only treatment conditions in which the subjects did not receive instruction in reading or spelling. These researchers used auditory and visual perceptual training as the treatments, with discrimination as the primary emphasis. The auditory discrimination training required subjects to discriminate between isolated sounds, letters, and words with background noise present. Visual discrimination training started with form and shape discrimination, and progressed to letter and word configurations.

Critique. The use of commercial reading programs as a method for modality-based instruction was questioned by several authors (Arter & Jenkins, 1977; Jones, 1971) who doubted that basal readers offer modality-pure instruction. The phonic versus sight word distinction was also challenged by critics who did not see either method as involving a single modality. Waugh (1973) doubted that experienced readers rely solely on the reading approach featured in a short-term experiment and speculated that readers use the method they are most familiar with when the dependent measures are presented. Austin and Donovan (1978b) claimed that many of the modality-based treatments are too homogeneous to be considered as distinct experimental conditions. Modality discrimination training, as applied by Sabatino, Ysseldyke, and Woolston (1973), did not involve direct instruction in reading

words, yet dependent measures required the subjects to read. Learning to read and learning to spell involve both the visual and auditory modes, and attempts to separate the two may be artificial and fruitless.

Results

Significant findings. Six of the 18 research studies included in this review reported significant modality by method interactions (Austin & Donovan, 1978a; Bursuck, 1971; Daniel & Tacker, 1974; Foster, Reese, Schmidt, & Ohrtman, 1976; Lilly & Kelleher, 1973; Wepman & Morency, 1975). These results were interpreted as evidence that subjects placed in instructional settings congruent with their modal strength performed significantly higher on the dependent measure than subjects placed in instructional settings that featured a non-preferred modality. The studies represented a variety of designs, subject characteristics, measures, and treatments.

Lilly and Kelleher studied a group of special education students labeled as educationally handicapped, Bursuck selected students with reading problems, and the other four studies involved regular education students. With the exception of Bursuck's tenth grade subjects, all other subjects were in the elementary grades. Treatments included phonics and sight word approaches, reading and listening, and commercial reading programs. None of the studies considered kinesthetic modal preferences. Austin and Donovan

included a control group, and Bursuck and Wepman and Morency designated a no-preference group of subjects. Foster et al. maintained that their significant results may be attributed to procedures for selection of subjects with extreme modal preferences. The six research efforts do share one common characteristic: all used analysis of variance to analyze the data.

Non-significant results. In 12 of the 18 investigations, non-significant results for a modality by method interaction were reported (Bruininks, 1970; Gallistel, Curran, & Hawthorne, 1973; Harter, 1981; Miller, 1974; Newcomer & Goodman, 1975; Robinson, 1972; Ringler & Smith, 1973; Sabatino & Dorfman, 1974; Sabatino, Ysseldyke, & Woolston, 1973; Smith, 1971; Vandever & Neville, 1974; Waugh, 1973). These results did not support the hypothesis that learners will perform higher on dependent measures when mode of instruction is matched to a modal strength, nor did they disprove the above hypothesis. Very few similarities may be found within this group when design, sample, measures, treatments, and analysis are compared.

Critique. The research studies reporting significant results were not unlike those reporting non-significant results. The group of six studies with results supporting the practice of matching modal strength to modality emphasized in instruction did not have a common attribute which may be used to explain why, as a group, they arrived at significant results. The only authors who attempted to

make a case as to why their approach resulted in significant findings were Foster, Reese, Schmidt, and Ohrtman (1976), and their findings lacked replication.

Several of the studies with significant results contained flaws which, for some reviewers, discredited the positive outcomes. Austin and Donovan (1978a) admitted that a limitation of their study was a failure to control for teacher competence. Indeed, the students of superior teachers had higher achievement scores than those of average or poor teachers involved in the study. In addition to this factor, all of the superior teachers used the visual reading program. Arter and Jenkins (1977) reported that Bursuck (1971) did not give the reader an adequate report of instructional and experimental procedures. This omission would preclude replication of Bursuck's study, or a classroom application of his methods. All of the studies reporting significant results, with the exception of Wepman and Morency (1975) who used a battery of unstandardized perceptual tasks, measured modal strength or deficit using normed tests of questionable reliability.

Harter's (1981) lone example of single subject research did not give the single subject approach an adequate trial in the area of modality-based instruction research. Harter's study assigned students to individualized spelling interventions based on the results of the Swassing-Barbe Modality Index, an instrument that does not have the reliability required for application of results

to individual students. Further, the instrument does not feature academic content, and it is possible that skill in sequencing plactic tokens is not directly applicable to an academic skill such as spelling.

In summary, due to unreliable measures of modality, comparison of group performances, limited study of children with learning problems, lack of modality-pure treatments, and reliance on the auditory/visual distinction of modal preference, the research dealing with modality-based instruction is equivocal at best. The utility of matching a learner's modal preference to modality featured in instruction has been neither proven nor disproven in educational research literature. The major contribution to date of research investigating a modality by treatment interaction has been to eliminate a number of research procedures that do not result in data that may be applied to the question of effectiveness of individualized modality-based instruction.

Published Reviews of Modal Preference Research

Conclusions of Reviewers

A search of the professional educational literature resulted in ten articles that reviewed research on the effectiveness of matching instruction to learners' modal preferences (Arter & Jenkins, 1977; Austin & Donovan, 1978b; Derevensky, 1978; Jones, 1971; Kampwirth & Bates, 1980; Larivee, 1981; Miller, 1979; Patridge, 1976; Silverston & Deichmann, 1975; Tarver & Dawson, 1978). None

of the reviewers found a body of research to support a classroom application of matching modality of instruction to learners' modal preferences. At best the research results were labeled "divided" (Austin & Donovan, 1978b, p. 14), or "controversial" (Patridge, 1976, p. 22). Derevensky found his review of modality research resulted in more questions than answers.

Rationales for Lack of Empirical Support

Several reviewers speculated about the lack of empirical support for teaching students with methods that match their modal strengths. Arter and Jenkins (1977) were the only reviewers to directly state that the modality model may be invalid. According to Tarver and Dawson (1978), modality may not be the most important variable to consider in either learners or tasks. Several reviewers mentioned lack of reliable instruments to measure modality as one possible reason why research has not supported modality-based instruction. Derevensky (1978) cited the preponderance of reading treatments, which cannot be accurately defined as auditory or visual methods, as a methodological flaw in much of the research he reviewed. Larivee (1981) saw sampling problems as limiting the interpretations which may be made based on modality research to date.

Because the vast majority of modality research studies compared group performances, Jones (1971) was of the opinion that significant effects for individuals have been overlooked. "The factor of

individual differences has been seen less as a point for research than as an annoying variable accounting for many of the conflicting findings of modality research" (1971, p. 2). Patridge (1976) concluded that there is evidence that individuals have profited from instruction that emphasized the individual's modal preference.

Need for Further Research

Half of the reviewers (Austin & Donovan, 1978b; Derevensky, 1978; Jones, 1971; Patridge, 1976; Silverston & Deichmann, 1975) concluded that there is a need for more research pertaining to the question of matching modality of instruction and preferred modality of the learner. Derevensky was of the opinion that such research should be a high priority. Tarver and Dawson (1978) concluded that there have been enough replications to discredit the use of modality-based instruction. The remaining reviews did not mention the issue of future research.

A Study of Input/Output-Modality Pairings and Math Performance

The inclusion criteria for this review of the literature stipulate that studies consider the effects of instruction matched to a learner's modal strength. This requires an assessment of modal preference prior to assignment to experimental groups. A study by Webster (1980) did not assess modal preference prior to treatment, but his study does provide some information applicable to this discussion of modal preference.

Rationale

After studying modality research, Webster observed that the variable of modality may be more complex than previously assumed. The question of modal preference may not involve auditory/visual distinctions, or even auditory/visual/kinesthetic distinctions. To date, few researchers have focused on higher level combinations of modality of stimulus and modality of response. An objective of Webster's study was comparison of short term memory of math-disabled and math-proficient groups as a function of input/output modality interactions.

Procedures

Webster's research was a group study involving a mildly math-disabled group, a severely math-disabled group, and a math-proficient group. The two math-disabled groups were comprised of students labeled as learning disabled by the school system. The math-proficient group was selected from a population of non-handicapped students. Assignment to groups was based on arithmetic achievement, as measured by the Wide Range Achievement Test. A total of 73 subjects were involved in the study.

Treatment procedures involved aural and visual presentations of strings of seven upper case consonants and seven digits. Subjects responded verbally and graphic symbolically immediately after each type of presentation. Presentations were sequenced to control for practice, fatigue, and rehearsal effects. Aural and

visual conditions were separated by one week, and each subject was tested individually.

Results

Webster's results were significant for main effect of input modality, with visual input superior to aural input. Further, significant differences were found between input/output strengths demonstrated by the math-proficient group (visual/graphic) and the math-disabled groups (visual/verbal). Webster pointed out that successful performance in the visual/graphic modality pairing is instrumental to successful school achievement in the later grades. The math-disabled groups were found to be most successful under the visual/verbal combination, a condition not commonly found in academic instruction, practice, and measures of achievement.

Conclusions

Webster concluded that although input/output modality preferences may undergo changes as a result of maturation, teachers should attempt to identify learner's modal preferences and orient instruction toward strengths. It was recommended that assessment be based on curriculum rather than norm-referenced tests to improve the interface between diagnostics and instruction. Webster speculated that rigidity of educational systems and insensitivity to individual learning styles may create unsuccessful learners.

Critique

Webster's approach to modality research offered insights to a new dimension of the modality variable. The consideration of a more

complex pairing of input/output modalities may be an important distinction between successful and unsuccessful math students. The analysis of data on a group basis did not provide insight into characteristics of individual learners, yet the author concluded that individualized instruction should consider modal preference. The recommended classroom instruction is based on an assessment using a norm measure and performance on a task that is not typically found in the classroom. Although Webster's research is an intruiging new direction for modality research, the research design does not permit application of the findings directly to the classroom setting.

Summary

A review of 18 studies investigating the relationship between learners' modal preferences and modality featured in instruction revealed equivocal results. In 6 of the 18 studies there were modality-by-method interactions, and in 12 of the 18 studies there were not interactions. No relevant variables were found to distinguish the studies in which significant relationships were found. All 18 studies were found to have shortcomings involving at least one of the following areas: experimental control, valid and reliable measurement, distinctly different treatment conditions, appropriate sampling, or appropriate research design. Ten reviews of modality research also contained mixed results. Although none of the reviewers strongly recommended modality-based instruction,

neither did the majority totally dismiss the possibility that modality may be an important factor in learning. One study (Webster, 1980) took a different approach to modality research and considered input/output modality pairings and math performance. Webster's study found a significant interaction between modality pairing and math achievement, and the study may have implications for future modal preference research.

Educators have both championed and criticized modality-based instruction for students, especially those students who are unsuccessful after "regular instruction." Research has not been entirely successful in answering teachers' questions about individualized instruction that considers the learner's modal preference, primarily because most modality research has involved group comparisons. Research methods that involve individual analysis of data, academic measures and treatments, direct measurement, and a pragmatic definition of modal preference may contribute some answers to questions about individual modal preferences and the part they play in the learning process.

CHAPTER III

METHOD

The research method outlined in chapter III consists of applied behavior analysis procedures used to examine the performance of individual learners. The questions asked in this study involved an individualized instructional setting and the variable of performance modes. The primary questions under investigation were

1. Do the performances of each subject show intraindividual differences in celeration values after a direct assessment of a math task across six performance modes?

2. What are the effects on celerations of math performances when direct instruction is provided in the performance modes identified as high and low during the assessment phase?

3. How does rate of performance in the six performance modes compare for measures taken before and after direct instruction in two of the performance modes for each subject?

4. What is the discrepancy between high and low celeration values for both the assessment and treatment phases for each subject?

5. Are there any patterns of performance among the subjects in terms of performance mode for the assessment, treatment, and post-treatment phases?

Collection and analysis of data were done on an individual basis with each subject. This chapter outlines the research method with descriptions of subjects, setting, conditions for each phase, task, measurement, interobserver agreement, and analysis.

Subjects

All four subjects in the study met the eligibility criteria for the University of Florida's Multidisciplinary Diagnostic and Training Program (MDTP). The eligibility criteria for the MDTP were as follows:

1. Enrollment in public school,

2. Current grade placement of kindergarten through sixth grade,

3. Placement in any school program including regular classes, special education classes, or programs such as Chapter I,

4. Referral by school or parents for complex learning, behavioral, and/or medical problems,

5. Parental permission for participation in the program.

The subjects selected from the population of MDTP clients all completed the diagnostic portion of the program and then were assigned to placements in the MDTP Diagnostic Classroom. Each subject was referred for a learning problem, and the educational diagnostic data for each subject indicated math performance below current grade level placement. Immediately following approval of the research proposal, the first four MDTP

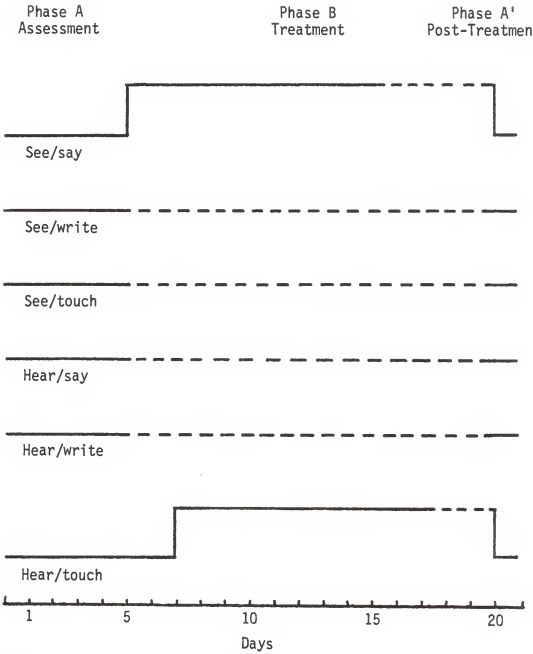
students who entered the classroom and met the above criteria were selected for the experiment (see Appendix A for a summary of pertinent characteristics describing each subject).

Setting

The research took place in the MDTP Diagnostic Classroom at the College of Education at the University of Florida, Gainesville, Florida. (There was one exception to this: the Phase A' measures for Subject 1 were collected in the subject's public school.) The Diagnostic Classroom facilities include a main classroom space and adjoining cubicles used for tutoring, small group instruction, and office space. Each experimental session took place in the same 2.1 m by 3.4 m cubicle where the student and instructor worked privately. Subjects' placements in the Diagnostic Classroom were from three to six weeks, during which time the child attended the entire school day. The classroom schedule included writing, reading, language, math, and storytime in the morning, and physical exercise, art, and tutoring after lunch. Each student was scheduled into academic subjects in a different sequence. The same instructor conducted each experimental session, and sessions for each child were held at a consistent time during the academic periods between 8:45 and 11:30 every morning.

Conditions for Each Phase

The research design consisted of three phases: an assessment phase, a treatment phase, and a post-treatment phase. Figure 1 illustrates an example of the research design with a hypothetical



Note. ——— = Independent variable in contact with subject

– – – – = Independent variable not in contact with subject

| = Beginning of new phase

(Notation system from Johnston & Pennypacker, 1980)

Figure 1. Experimental design for hypothetical subject.

subject. The structure of the design remained constant across all subjects, but the performance modes present during the treatment phase were determined on an individual basis. A person familiar with the following specifications observed experimental sessions at random and determined that the protocol was followed correctly.

Assessment (Phase A)

The six conditions. Throughout each phase, performance mode was the independent variable. The six performance modes present during Phase A were as follows:

1. See/say, in which the subject was given a printed sheet containing math facts and was required to say the answer aloud,

2. See/write, in which the subject was given a printed sheet containing math facts and a pencil, and was required to write the answer,

3. See/touch, in which the subject was given a printed sheet containing math facts and a hand-held calculator, saw the instructor point to each fact, and was required to touch keys corresponding to the correct answer,

4. Hear/say, in which the subject heard the instructor say the math problem and was required to say the answer aloud,

5. Hear/write, in which the subject was given a pencil and blank paper, heard the teacher say the math problem, and was required to write the answer,

6. Hear/touch, in which the subject was given a hand-held calculator, heard the instructor say the math problem, and was required to touch the keys corresponding to the correct answer.

Specifications for assessment. During the assessment phase, the same instructor met individually with each subject during the same period each day. A script containing the instructor's procedures appears in Appendix B. The instructor presented six probes that involved basic math facts at the same level of difficulty in the same operation and different sets of specific facts for each performance mode. The probes were presented in a different order on each day in the assessment phase. Each day the instructor started at a different place in the probe.

A session began with the instructor modeling the required performance mode for ten seconds before the student was required to perform. The teacher modeled facts from a portion of the probe other than the subject's starting point. Following the modeling, the student was required to perform the same task for one minute. Rates were recorded as number of correct responses and number of error responses per minute (e.g., 27/4). This protocol for one-minute timings was followed in all experimental phases. The teacher did not give the student feedback during this phase, but did verbally praise each student for attempting each probe. The instructor entered the data on an AC-4 chart (Berquam, 1979), but did not share the chart with the subject.

Duration of phase. Phase A was five school days in length and served to establish the two performance mode conditions with the highest and lowest celeration values for each subject. If for

any reason celeration values did not differentiate high and low performance modes for a subject, the conditions with the highest and lowest rates of correct movements per minute after five days of assessment were designated. White and Haring (1980) recommended five days as a sufficient number of days in which to establish a reliable trend in initial assessment of an academic task.

Treatment (Phase B)

The two conditions. The treatment phase involved two conditions: performance modes with the highest and lowest celeration values, individually determined for each subject on the basis of data from Phase A. Phase B featured a multiple baseline with Condition I beginning directly after the assessment phase, and Condition II continuing the conditions established in Phase A for two additional days before beginning treatment. The multiple baseline feature can indicate the effect of generalization of instruction from one performance mode to the other. Assignment of performance modes to Conditions I and II was determined by a flip of a coin for each subject. Time of instruction, setting, instructor, reinforcement, and level of task were held constant during the treatment phase. Only the variable of performance mode used for modeling, practice, and measurement, and the specific math facts on the two probes varied between the two conditions.

Specifications for treatment. Instruction during the treatment phase was structured the same for Condition I and

Condition II. A script detailing the procedures for Phase B may be found in Appendix B. Subjects received ten minutes of instruction in each performance mode condition, with the order of presentation alternated each session. Instruction began with the teacher modeling the behavior required of the subject. The child then practiced the same behavior and received immediate feedback as to the correctness of his or her responses. If a response was in error, the instructor supplied the correct answer.

During the last two minutes of the instructional session, the subject performed for one minute on the same probe used for modeling and practice. The one-minute timings were conducted using the same procedure specified for Phase A. The student and teacher charted the correct and error rates on the AC-4 Standard Behavior Chart (Berquam, 1979). If the subject's performance improved in relation to the previous day, he or she received a sticker as a reinforcer. The instructional procedures were repeated for the second condition each day.

Duration of treatment. The treatment phase was 11 days long for Subjects 1, 2, and 3, and 8 days long for Subject 4. Subject 4 was assigned to the Diagnostic Classroom for 14 school days, and data were collected every day except the child's first day in the classroom. Celeration values were calculated using the rates correct from the first and last days in Conditions I and II, excluding baseline days.

Post-Treatment (Phase A')

During the post-treatment phase, the six probes from Phase A were presented again in the same six performance modes. Procedures for presentation, task, and measurement for this phase were identical to the procedures for Phase A (see Appendix B). One set of six timings was taken on the third day of the post-treatment phase. The purpose of Phase A' was to determine if instruction was generalized to other performance mode conditions, and if rates achieved in other phases were maintained after instruction was withdrawn.

Task

Selection of Task

Each subject was assigned to probes containing a set of basic math facts in one of the four operations. Operation and level of difficulty of facts were determined individually for each subject. Data used for this decision were rates routinely collected during the MDTP diagnostic assessment, which was completed prior to placement in the Diagnostic Classroom. The MDTP educational assessment included three timings on each probe containing basic math facts. (Children below grade three are generally not administered the multiplication and division probes.) The highest rate of the three trials was considered for determining a set of basic math facts that were at instructional level, or rates correct less than criterion but greater than 10 digits per minute. The

set of math facts selected for each subject was not the target of other math instruction during the days the experiment was conducted.

Assignment of Facts to Probes

Probes for Phases A and A'. The same six probes were used for the same six performance modes throughout Phases A and A'. The set of basic math facts selected for each subject was randomly assigned to the six performance mode conditions, with each probe containing an equal number of different facts. For example, if sums to nine were selected for a subject, then a total of 30 different facts were involved. (Problems such as 2+0 and 0+2 were considered as the same fact.) The 30 facts would be randomly assigned to the six performance mode conditions, with each probe displaying 5 different facts and approximately 40 problems. On addition probes, the addends were reversed, and on multiplication probes, the multiplicand and multiplier were reversed within the probe. The probes and performance modes were randomly matched, and that match remained constant throughout Phases A and A'.

Probes for Phase B. The same set of math facts selected for Phases A and A' was used for Phase B, but the facts were randomly assigned to two probes. For example, referring to the set of 30 sums to nine, each probe would contain 15 different facts and approximately 40 problems. A flip of a coin determined which probe was assigned to Condition I, and the remaining probe was assigned to Condition II.

Measurement

In a discussion of modality preference, Arter and Jenkins (1978) recommended direct, daily measurement as a way to "bypass the problems of reliability often associated with standardized measures" (p. 297). The measurement tactics selected for this study were designed to result in reliable data directly applicable to individualized instruction.

Rates per Minute

The terms "rate" and "frequency" are used interchangeably in professional literature to mean movements per unit of time. Starlin (1971) studied thousands of charts from teaching projects that displayed rate data and concluded that "pupil performance rates are used because this is the most legitimate measure of a youngster's academic performance" (p. 393). Haring and Schiefelbusch (1976) recommended use of rate data because it is a sensitive measure of pupil performance that indicates both accuracy and fluency of performance.

Throughout each phase, measurement was done on a daily basis for each performance mode condition of the phase. During Phases A and A', this involved six measures taken daily; Phase B involved two measures taken daily. The measurement was rate of correct digits per minute and number of error digits per minute for the see/write, see/touch, hear/write, and hear/touch performance modes. The measurement for the see/say and hear/say performance modes was

numbers said correctly and numbers said in error per minute. Measures were expressed in the following form: 43/2, with the first value noting correct responses per minute, and the second value noting errors per minute. Rates for each one-minute timing were recorded on the AC-4 chart.

Celeration

Trends in rate data may be summarized with celeration values or celeration lines on charts (Koorland & Martin, 1975; White & Haring, 1980). The words acceleration and deceleration have the same root, celeration, which connotes speed. Celeration values representing improving trends are preceded with a multiplication sign (e.g., x2.81), and celeration values representing declining trends are preceded with a division sign (e.g., ÷1.35). Celeration values indicate rate of learning. For example, a x1.10 celeration value represents a slower rate of learning than a x3.67 celeration value.

For the purposes of this investigation, celeration values were calculated using an adaptation of Koorland and Martin's formula:

$$\text{Acceleration } (x) = \frac{\text{Greater end of the phase rate correct}}{\text{Smaller beginning of the phase rate correct}}$$

$$\text{Deceleration } (\div) = \frac{\text{Greater beginning of the phase rate correct}}{\text{Smaller end of the phase rate correct.}}$$

Celeration values were calculated for Phase A and Phase B. The celeration values were compared within phases only, as the standard units of time were different for Phases A and B.

Interobserver Agreement

During the experiment, the data for three experimental sessions were collected by a second observer in the same manner as the data were collected by the instructor. The two sets of data were statistically compared, resulting in a value for interobserver agreement. The .90 standard suggested by Miller (1975) was used as criterion for adequate reliability of the measures. The interobserver agreement data are presented in Appendix C. The measures were reliable, with a 1.00 agreement between the two sets of measures.

Analysis

Data were analyzed by comparison of celeration values, visual inspection of the charts displaying rate data, and comparison of rates per minute. Separate analyses were conducted for each subject in response to the first four experimental questions. The data from all four subjects were used to determine if any patterns of performance were present among the subjects.

In addition to visual inspection, the specific measures used to answer the experimental questions were as follows:

1. Celeration values for all six performance modes from Phase A were used to answer Question 1.

2. The two celeration values from Phase B were used to answer Question 2.

3. Rates per minute from the first day of Phase A were compared with those from Phase A' to answer Question 3.

4. The difference between high and low celeration values from Phases A and B were used to answer Question 4.

5. Celeration rankings, celeration discrepancies, and generalizations made among the six performance modes were used to answer Question 5.

Summary

The research method was designed to arrive at data that may be used to answer the research questions. Subjects were elementary-aged students with learning problems assigned to a Diagnostic Classroom. The independent variable was performance mode: see/say, see/write, see/touch, hear/say, hear/write, and hear/touch. The dependent variables were rate of learning (celeration) and rate of performance (responses per minute). Rate data were collected through one-minute samples of performance on a task involving basic math facts. The research design included three phases: assessment, treatment, and post-treatment. Analysis involved within subject comparisons of celeration values, charted data, and rates correct per minute, and a between subject comparison of patterns of performance.

CHAPTER IV

RESULTS

In chapter IV, results are reported in response to the experimental questions. The chapter includes an overview of the principal findings, individual data summaries for each subjects, and a report of comparisons among the subjects. The principal findings are presented as summary statements, and supportive data are in the subsequent sections of this chapter and in the raw data displayed in Appendix D. Results pertaining to the four experimental questions for each subject are outlined in the individual data summaries. Patterns of performance among the four subjects are reported in the final section of this chapter.

Principal Findings

The following statements are a brief summary of the results of this investigation. The data were collected daily as rates per minute, and then were summarized as celeration values that indicate the speed with which a performance is changing. The data were also plotted on logarithmic charts and were analyzed using visual inspection to detect trends and other characteristics of performance. The principal findings are as follows:

1. Intraindividual differences were detected after a direct assessment of math performance across six performance modes.

2. Each subject's rankings of performance modes was different when celeration values were ranked from high to low.

3. After direct math instruction using high and low performance modes, each subject's math performance improved, but improvement took place at different rates within subjects and among subjects.

4. Improved performance after direct instruction in high and low performance modes did not always generalize to the other four performance modes, and each subject made different generalizations.

5. The discrepancies between high and low celeration values were greatest before instruction.

6. When math task was at the frustration level for an individual, a meaningful assessment of performance mode was confounded.

Individual Data Summaries

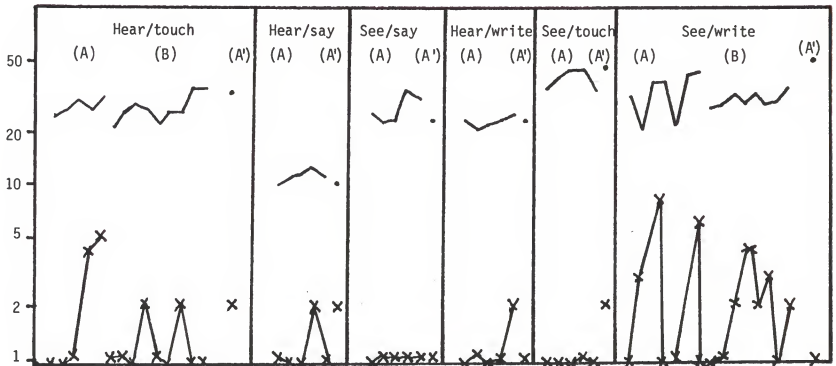
Effective strategies for individualized instruction must be based on knowledge of the individual. The following individual data summaries present data gathered on four subjects, all of whom were experiencing learning problems, especially in the area of mathematics. Each textual report is accompanied by a graphic summary of the data (see Figures 2 through 5). Rates per minute are reported as rate of correct responses/rate of errors (e.g., 45/6). The basic math facts used in this investigation meet Ashlock's (1976) definition of math facts as simple number sentences with one-digit

addends for addition and subtraction sentences, and one-digit factors for multiplication and division sentences. (The addends in the number sentence 15-8=7 are the numbers 8 and 7; the factors in the number sentence 45÷9=5 are the numbers 9 and 5.)

Subject 1

Subject 1 was a female aged 11 years whose public school placement included a regular fifth grade class and a resource room for Specific Learning Disabled students. Subject 1 was referred to the Multidisciplinary Diagnostic and Training Program (MDTP) for learning problems, and just prior to her entrance in the Diagnostic Classroom, she performed at the 3.4 grade level on the Key Math Diagnostic Arithmetic Test (see Appendix A for additional descriptive information). All math probes for Subject 1 contained addition facts with sums from 10 through 18. The experimental sessions for Subject 1 took place between 8:45 a.m. and 9:05 a.m. each school day. The measures for Phase A' were collected in the public school resource room setting.

1. Are there intraindividual differences in celeration values after a direct assessment of a math task across six performance modes? Comparison of celeration values and visual inspection of Subject 1's data both indicated intraindividual behavioral differences among six performance modes. Celeration values and visual inspection showed the performance modes hear/touch, hear/say, see/say, hear/write, and see/touch as having positive trends in rate



Phase A ranking		Phase B ranking		Celeration discrepancy	
High:	Hear/touch	High:	Hear/touch	Phase A =	2.68
	Hear/say	Low:	See/write	Phase B =	0.42
	See/say				
	Hear/write				
	See/touch				
Low:	See/write				

Figure 2. Subject 1, rates per minute on probes containing addition facts (sums 10-18), across six performance modes.

of correct responses. Data from the last day of Phase A (which was a Monday) showed a drop in rate correct for hear/say, see/say, see/touch, and see/write, and the lower measures from Monday resulted in celeration values that did not accurately depict degree of change in the rates per minute. Visual inspection detected steeper ascending trends in the hear/say, see/say, and see/touch data sets than were noted by celeration values. The celeration value for see/write represented a descending trend in rate correct, but a visual inspection revealed a very erratic performance with errors ranging from 0 to 8 and correct digits ranging from 21 to 38.

Performance mode celeration values ranked from highest to lowest are as follows: hear/touch (x1.29), hear/say (x1.20), see/say (x1.19), hear/write (x1.04), see/touch (x1.00), and see/write (÷1.39). Several of the performance modes have very similar celeration values, but there is a marked difference in the values for the highest (hear/touch) and the lowest (see/write) performance modes, primarily due to the negative celeration value for see/write.

Error rates were two or less per minute for all performance modes except hear/touch and see/write (the high and low performance modes respectively). During Phase A, error rates in the hear/touch and see/write performance modes tended to increase as rate correct accelerated. The hear/touch performance mode had the highest celeration of correct responses, and the celeration for the error

rate in the hear/touch performance mode was x5.00. The see/write performance mode had a negative celeration for rate correct, and a x1.00 celeration for rate of errors, which indicates an unchanged performance. The high rate of errors occurred in the middle of the phase, and thus did not impact the celeration value for errors in the see/write condition. In the case of error rates for Subject 1, only visual inspection of charted data gave an accurate summation of performance.

The five Phase A measures in the hear/say performance mode represented a much slower performance than all other performance modes. Subject 1's rates in hear/say ranged from 10/1 to 13/2 numbers per minute. A visual inspection of the assessment phase rates made it apparent that the hear/say performance was by far the slowest performance. Because of the low rates in hear/say, an increase of just a few numbers per minute represented a large proportion of the total numbers correct. Celeration is represented as a ratio, and the hear/say celeration value of x1.20 was the second highest celeration value for Subject 1. Based on frequency of movement alone, hear/say is the least proficient performance mode for Subject 1.

2. What are the effects on celerations of math performances when direct instruction is provided in the performance modes identified as high and low during the assessment phase? Analysis of celeration values and a visual inspection of Phase B charts

indicated that when direct instruction in high and low performance modes was introduced, Subject 1's rate of correct responses increased in both performance modes. Performance in hear/touch improved at a x1.71, and performance in see/write improved at a x1.29 celeration value. The hear/touch rate on the first day of Phase B was lower than the starting rate for see/write, and hear/touch rates increased faster than did the rates for see/write. The end rates per minute for the two conditions were very similar: 36/0 for hear/touch, and 36/2 for see/write.

The frequency of errors during Phase B was different across the two performance modes, with total errors under see/write at 14, or twice the errors committed under hear/touch. Error rates per minute for hear/touch were 2 or less throughout the treatment phase. See/write error rates ranged from 0 to 4 per minute, and did not show any consistent relationship to increasing or decreasing rates of correct responses. Both rate of errors and rate of correct responses in the see/write performance mode displayed "bounce," or up and down patterns in the charted data.

3. How does rate of performance in the six performance modes compare for measures taken before and after direct instruction in two of the performance modes? For the two performance modes in which there was direct instruction, Subject 1's rates of performance increased from Phase A to Phase A'. In addition, the student's performance in see/write improved to 50/0 digits per

minute, which is 14 digits greater than the end rate of Phase B. (The Phase A' probe contained fewer number of different math facts than did the Phase B probe.) Of the four performance modes not targeted for direct instruction, only one (see/touch) improved from the first to the last day of the experiment. The end rates for hear/say, see/say, and hear/write were strikingly similar to those recorded over three weeks earlier.

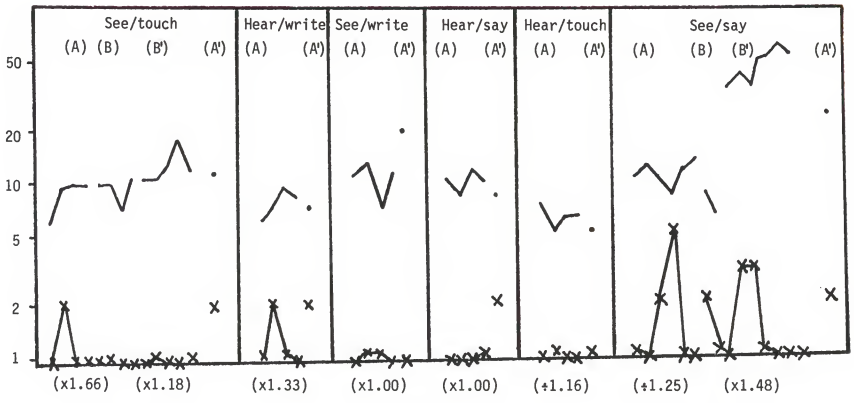
4. What is the discrepancy between high and low celeration values for both the assessment and treatment phases? For Subject 1, the difference between high and low celeration values from Phase A was 2.68. The decelerating trend in the see/write mode was treated as a negative number, thus resulting in a relatively large discrepancy. The celeration values from Phase B only differed by a .41, indicating that with the addition of direct instruction, the two performances improved at a more similar rate of change.

Overview of results, Subject 1. The rates correct for Subject 1 in the hear/touch performance mode increased faster than did the rates correct for all other performance modes during Phases A and B. Error rates for hear/touch also increased during Phase A, but error rates for hear/touch were low during Phase B when the student received modeling, practice, and feedback. Subject 1's erratic performance in see/write resulted in the lowest celeration values for Phases A and B, and she committed more errors using see/write than she did with any of the other five performance

modes. Subject 1's slowest performance across all phases was 10/1 numbers per minute in hear/say; Subject 1's fastest performance across all phases was 50/0 digits per minute, which was the Phase A' measure for see/write. After direct instruction was stopped, Subject 1 maintained or increased rates correct in the performance modes targeted for direct instruction, and increased proficiency in addition facts generalized only to the see/touch performance mode. The discrepancy between high and low performance mode celerations decreased from the assessment to the treatment phase.

Subject 2

Subject 2 was a male aged 11 years whose public school placement was a regular fourth grade class before he entered the Diagnostic Classroom. His placement was changed to a full-time Specific Learning Disabilities classroom after he left the Diagnostic Classroom. Subject 2 was referred to the MDTP for learning problems, and just prior to his entrance in the Diagnostic Classroom, Subject 2 performed at the 3.7 grade level on the Key Math Diagnostic Arithmetic Test (see Appendix A for additional descriptive information). All math probes for Subject 2 contained subtraction facts with minuends from 10 through 18. The experimental sessions for Subject 2 took place between 9:15 a.m. and 9:35 a.m. each school day.



Phase A ranking

High: See/touch
Hear/write
See/write
Hear/say
Hear/touch
Low: See/say

Phase B ranking

High: See/say
Low: See/touch

Celeration discrepancy

Phase A = 2.91
Phase B = 0.30

Figure 3. Subject 2, rates per minute on probes containing subtraction facts (minuends 10-18), across six performance modes.

1. Are there intraindividual differences in celeration values after a direct assessment of a math task across six performance modes? Celeration values and charted data from the assessment phase did indicate intraindividual behavioral differences for Subject 2. Phase A contained measures for four days, as the student was absent one day during the assessment phase. Phase A celeration values for Subject 2 were as follows (ranked from highest to lowest): see/touch (x1.66), hear/write (x1.33), see/write (x1.00), hear/say (x1.00), hear/touch (÷1.16), and see/say (÷1.25). The two negative celeration values indicated that the student performed at a slower rate on the last day of Phase A than on the first day of the phase. Selection of high and low performance modes through visual inspection of the charts yielded the same results as did the comparison of celeration values, but none of the performance trends were dramatically different from the others. See/touch (high performance mode) was the only condition in which rates always increased or stayed at the same level, and the error rates for see/touch were consistently two or less per minute. Performance in the see/say condition (low performance mode) showed a decreasing trend in the rate of correct responses and an increasing trend in the rate of errors. For the assessment phase, all rates per minute for all performance modes ranged between 5/1 and 13/1, which were relatively slow rates for performing math facts.

2. What are the effects on celerations of math performances when direct instruction is provided in the performance modes identified as high and low during the assessment phases? During the first four days of Phase B, the celeration trends for Subject 2 did not indicate improvement in math performance for either experimental condition. Performance in the see/touch condition was maintaining at approximately 10 correct digits per minute, and performance in the see/say condition was declining with the correct rate of numbers per minute falling from 12 (baseline) to 6 (day four). The researcher and the instructor determined that it would be appropriate to change the task, and the number of different facts on each probe was reduced from 22 to 7. The set of subtraction facts on the Phase B probes then involved facts with minuends of 10, 11, and 12. The celeration values reported for Subject 2 reflect change in performance only across the last five days of instruction, during which time probes containing seven different math facts each were used for modeling, practice, and measurement.

After introduction of a simplified probe on day five of Phase B, Subject 2's math performance in both see/touch and see/say improved with direct instruction. Math performance in the see/say performance mode (determined as low in Phase A) improved at a x1.48 celeration, and performance in the see/touch performance mode (determined as high in Phase A) improved at a x1.18 celeration.

With the introduction of the simplified probe, there was a large jump in the see/say rate, from 6/1 to 33/0 numbers per minute. The see/touch rate did not change the day after the simplified probe was introduced, but remained at 11/0 digits per minute. The see/touch performance has a top rate of 17/2, but the fastest rate in see/say was 55/0. A visual inspection of the charted data revealed the very different characteristics of the two performances, with see/say as the most proficient performance. The performance modes identified as high and low for Phase B were the reverse of those identified in Phase A.

3. How does rate of performance in the six performance modes compare for measures taken before and after direct instruction in two of the performance modes? The probes used in Phase A' were identical to those used in Phase A, and therefore were the more difficult set of probes. It is logical that when the see/say and see/touch measures for Phase A' were compared with the end rates for Phase B, both rates correct decreased; however, Phase A' measures for see/say and see/touch were faster than the rates from day one of the experiment. The rates for see/write (not a target of instruction) nearly doubled from the beginning to the end of the experiment. The beginning and end rates for hear/write improved by one additional digit correct and one less digit incorrect. The rates per minute for hear/say and hear/touch decreased and were lower on the last day of the experiment than they were on the first.

4. What is the discrepancy between high and low celeration values for both the assessment and treatment phases? For the assessment phase, the discrepancy between high and low celeration values was 2.91. The decelerating trend for see/say was treated as a negative number. With the addition of direct instruction featuring a consistent use of performance mode, the celeration discrepancy reduced to .30 for Phase B, and high and low performance modes were the reverse of Phase A rankings.

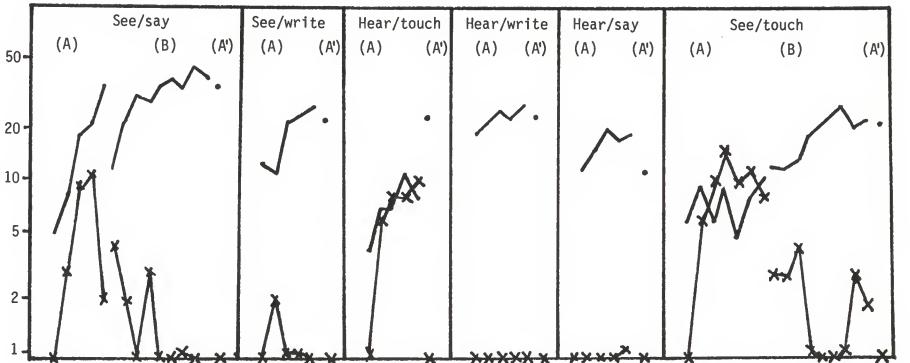
Overview of results, Subject 2. Subject 2's performance on math probes containing subtraction facts did show intraindividual behavioral differences across the six performance modes. In the assessment phase, see/touch was identified as the high performance mode, and see/say as the low performance mode. All rates during Phase A were relatively slow, with 13/1 per minute as the fastest performance. After direct instruction was introduced using the see/touch and see/say performance modes, neither of the math performances improved. New probes containing fewer different facts were introduced, and rates in the see/say performance mode showed a large increase in rate correct with a consistently low error rate. After introduction of the simplified probe, the rates for see/touch showed only a small increase. The high and low performance modes for Phase B were the reverse of those identified in Phase A. After instruction was stopped, the rates for see/say and see/touch dropped, although they were above the rates from day one of Phase A.

Improved math performance only generalized to the see/write performance mode. The celeration discrepancies between high and low performance modes decreased from the assessment phase to the treatment phase.

During the study, the instructor observed Subject 2 to count (frequently using his fingers) using two different strategies to arrive at an answer. At times, Subject 2 started with the subtrahend and counted up to the minuend, and at other times he started with the minuend and counted down to the subtrahend. Rate of see/say subtraction facts improved the most during the treatment phase, and see/say was the performance mode in which the student's hands were free to be used for counting. In the see/say performance mode, Subject 2 did not have to put his pencil or calculator down to count on his fingers and arrive at an answer.

Subject 3

Subject 3 was a male aged 8 years whose public school placement included a regular second grade class with supplementary speech and language therapy. Subject 3 was referred to the MDTP for learning problems and language problems. Just prior to his entrance in the Diagnostic Classroom, Subject 3 performed at the 1.7 grade level on the Key Math Diagnostic Arithmetic Test, which was below his grade placement of 2.8 (see Appendix A for additional descriptive information). All math probes for Subject 3 contained addition facts with sums of six through nine. The experimental



Phase A ranking

High: See/say
See/write
Hear/touch
Hear/write
Hear/say
Low: See/touch

Phase B ranking

High: See/say
Low: See/touch

Celeration discrepancy

Phase A = 8.20
Phase B = 1.15

Figure 4. Subject 3, rates per minute on probes containing addition facts (sums 6-9), across six performance modes.

sessions for Subject 3 took place between 10:50 a.m. and 11:10 a.m. each school day.

1. Are there intraindividual differences in celeration values after a direct assessment of a math task across six performance modes? The data for Subject 3 show pronounced intraindividual differences in charted data and in celerations across performance modes. The highest celeration was a x7.00 in the see/say performance mode. (Note, this was growth before instruction.) The other celeration values in descending order were see/write (x2.15), hear/touch (x2.00), hear/write (x1.47), hear/say (x1.46), and see/touch (÷1.20). Using celeration values, see/say was designated as high performance mode, and see/touch was labeled low performance mode.

Visual inspection of Phase A charts also identified see/say as the high performance mode and see/touch as the low performance mode. The see/say trend was characterized by large increases in rates from 5/0 on day one to 35/2 on day five. The see/say error rate also accelerated quickly to a top rate of 10 errors per minute, but errors dropped to 2 per minute on day five of the assessment phase. The see/write, hear/write, and hear/say performance modes all showed increases in rate correct and low error rates. Both of the conditions involving the touch response showed accelerating errors, with several measures showing more errors than correct responses. The correct rate for see/touch (the low performance mode) showed an

up and down pattern, with the final rate for Phase A slower than the rate correct on the first day of assessment.

2. What are the effects on celerations of math performances when direct instruction is provided in the performance modes identified as high and low during the assessment phase? After nine days of direct instruction, Subject 3's rates in the see/say performance mode improved at a x3.00 celeration. The see/say chart depicted a decrease in the error rate as the correct rate increased. Subject 3's fastest performance in Phase B was 44/0 numbers per minute using the see/say performance mode. After equal instruction in the see/touch performance mode, the celeration was x1.85. With the addition of modeling, practice, and feedback in see/touch, the error rate decreased. Total number of errors across Phase B also represented a difference between the high and low performance modes. In the high performance mode, see/say, 10 total errors occurred across the phase. In the low performance mode, see/touch, total errors numbered 18. Both celeration and chart analyses found see/say to be the high performance mode for Phase B, and see/touch to be the low performance mode for Phase B. Performance modes designated as high and low were consistent from Phase A to Phase B.

3. How does rate of performance in the six performance modes compare for measures taken before and after direct instruction in two of the performance modes? Subject 3 performed the math task at

a higher rate in five of the six performance modes when the rates from the last day of the experiment were compared to rates from the first day. Rates in the performance modes see/say, see/write, hear/touch, hear/write, and see/touch all increased between 6 and 31 additional correct responses per minute. The beginning rate for the hear/say performance mode was 13/2, and the end rate for hear/say was 12/0 numbers per minute. Improved performance in the other performance modes did not generalize to the hear/say condition.

4. What is the discrepancy between high and low celeration values for both the assessment and treatment phases? The discrepancy between celeration values decreased from Phase A where it was 8.20, to a difference of 1.15 in Phase B. The high and low performances for Subject 3, see/say and see/touch, do look very different during the assessment phase. Learning in both modality combinations improved during the treatment phase, but celeration was at a slower rate for see/say and a faster rate for see/touch, when compared to the trends in Phase A. In Phase B, the celerations became more alike, and the discrepancy decreased.

Overview of results, Subject 3. Subject 3's math performances in the six performance mode conditions were all different. The high performance mode, see/say, was characterized by a rapid increase in both error and correct response rates, although errors fell to 2 per minute on the last day of Phase A. The see/write, hear/write, and see/say trends all depicted increasing correct

responses and low error rates. The assessment data for both conditions involving the touch response showed high error rates that frequently exceeded the rate correct. During Phase B, both see/say and see/touch increased in rate correct and decreased in the rate of errors, but see/say had the higher celeration value and the faster end rate. Subject 3's improved math performances generalized to all other performance modes except hear/say. The celeration discrepancy between high and low performance modes was greater in Phase A than it was in Phase B.

Subject 4

Subject 4 was a male aged 12 years whose public school placement included a regular fifth grade class with supplementary speech and language therapy. Subject 4 was referred to the MDTP for learning, behavior, and medical problems. Just prior to his entrance in the Diagnostic Classroom, Subject 4 performed at the 2.5 grade level on the Key Math Diagnostic Arithmetic Test (see Appendix A for additional descriptive information). All math probes for Subject 4 contained addition facts with sums of zero through 18. The experimental sessions for Subject 4 took place between 8:45 a.m. and 9:05 a.m. each school day.

1. Are there intraindividual differences in celeration values after a direct assessment of a math task across six performance modes? Subject 4's assessment phase data did show intraindividual differences in chart trends and celeration values for rates

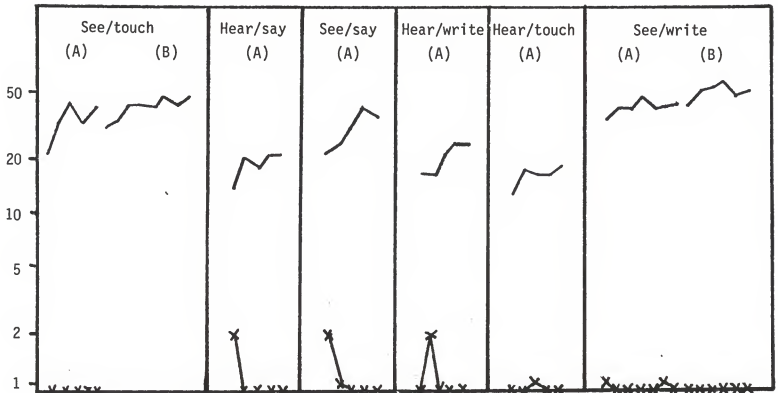


Figure 5. Subject 4, rates per minute on probes containing addition facts (sums 0-18), across six performance modes.

measured in the six performance modes. All of the celerations for all performance modes depicted improving trends, as did a visual inspection of the charts. The rate of change for each performance mode ranked from greatest to least change were see/touch (x1.81), hear/say (x1.64), see/say (x1.60), hear/write (x1.52), hear/touch (x1.35), and see/write (x1.13). Based on a visual inspection of the assessment phase charts, see/touch and see/say showed very similar rates and improving trends. The end rate for see/touch was slightly higher than the end rate for see/say, and thus the performance was represented by a slightly higher celeration value. The trends for see/touch and see/say did not look very different on the charts. The see/write performance had the lowest celeration value, but it had the highest beginning rate. Based on visual inspection, the lowest performance mode during the assessment phase was hear/touch. Of all the performance modes, hear/touch had the slowest rates and increased at a relatively slow rate of change.

2. What are the effects on celerations of math performances when direct instruction is provided in the performance modes identified as high and low during the assessment phase? Subject 4 left the Diagnostic Classroom on the eighth day of Phase B. The celeration values for Phase B were calculated using the first six days of instruction for each condition. (There were two days of baseline data taken during Phase B.) The see/touch performance mode, the high performance mode from Phase A, continued to show the

greatest change during Phase B with a celeration value of x1.47. Rates in the see/write condition showed the least amount of proportional change with a celeration of x1.21, which was consistent with the rankings from Phase A. Subject 4 was very accurate in using both high and low performance modes. Even though the celeration values differed for the two performance modes in Phase B, the absolute change from low rate correct to high rate correct was approximately the same for both conditions. See/write increased by 15 digits correct, and see/touch increased by 16 digits correct per minute. Because celeration is a ratio, similar amounts of absolute change did not result in equivalent celerations.

3. How does rate of performance in the six performance modes compare for measures taken before and after direct instruction in two of the performance modes? The data for Subject 4 did not include measures for Phase A'. Attempts were made to collect end rates after the subject left the Diagnostic Classroom, but the researcher was unable to arrange a time for data collection in the regular classroom before the conclusion of the school year.

4. What is the discrepancy between high and low celeration values for both the assessment and treatment phases? The differences between high and low celeration values from Phases A and B were .68 and .26, respectively. All celeration trends for both phases were improving, so no negative numbers were involved. The discrepance between celerations decreased from Phase A to

Phase B, indicating that the performances tended to improve at more similar rates of change after the introduction of direct instruction.

Overview of results, Subject 4. Subject 4 increased his rate of correct movements per minute in all six performance modes during the assessment phase. All measures for all phases had error rates of two or less per minute. Based on celeration values from Phases A and B, the high performance mode was see/touch and the low performance mode was see/write. Charted data did not depict see/write as the low performance mode; a visual inspection of Phase A charts revealed hear/touch as the low performance mode. During Phase B, rates correct increased for both see/touch and see/write performance modes. Absolute change using high and low rates for correct responses from Phase B showed an increase of 15 digits per minute for see/write and 16 digits per minute for see/touch. See/touch rates were slower than see/write rates, and because celeration is a ratio, see/touch had the highest celeration value for Phase B. No Phase A' measures were collected for Subject 4. The discrepancy between high and low celeration values was smaller in Phase B than it was in Phase A.

Patterns of Performance Among the Subjects

The fifth experimental question was the only question that required a comparison among subjects. This section presents data relating to the question: Are there any patterns of performance

among the subjects in terms of performance mode for the assessment, treatment, and post-treatment phases? Patterns of performance among the subjects will be presented in terms of intraindividual differences, celeration and direct instruction, modal patterns, celeration discrepancies, and generalizations among performance modes.

Intraindividual Differences

Celeration values from Phase A of the experiment did serve to distinguish intraindividual behavioral differences on a math task across six performance modes for each subject. When subjects performed a math task (without receiving instruction) using six different performance modes, once a day for five consecutive days, each subject's rate of performance increased or decreased at different rates of change in each performance mode. It was possible to select a high and low performance mode for each subject on the basis of celeration values from Phase A.

Each subject's ranked list of performance mode celerations from Phase A represented a sequence different from that of the other subjects. None of the subjects ranked lists show the see/write performance mode as the one in which rate of performance changed the fastest in Phase A. The performance modes with the highest celeration values from Phase A (for Subjects 1 through 4 respectively) were hear/touch, see/touch, see/say, and see/touch. The performance modes with the lowest celeration values from

Phase A (for Subjects 1 through 4 respectively) were the see/write, see/say, see/touch, and see/write performance modes.

Celeration and Direct Instruction

Phase B of the experiment involved direct math instruction in the two performance modes with highest and lowest celeration values from Phase A. All celeration values for all subjects for all conditions in Phase B were positive, indicating increased rates of performance. After direct instruction featuring a consistent use of performance mode for modeling, practice, and measurement, learning did occur, even in those performance modes identified as having low celeration values or negative celeration values from Phase A. Every student learned to perform basic math facts more proficiently in the performance modes that were targeted for direct instruction, but the learning did occur at different rates.

Modal Patterns

For three of the subjects, the performance mode with the highest celeration value from Phase A also had the highest celeration value in Phase B, and the performance mode with the lowest celeration value was also consistent across assessment and treatment phases. That is, the assessment phase data agreed with the treatment phase data as to which performance modes showed greatest and least amounts of change in learning for three of the subjects. Subject 2's data were not consistent with this finding, and the performance mode with the lowest celeration value from

Phase A improved the fastest with direct instruction. The task presented during assessment phase was at frustration level for Subject 2, and the high/low pattern from Phase A was reversed in Phase B (see individual analysis for Subject 2).

Celeration Discrepancies

Direct instruction narrowed the discrepancy between highest and lowest celeration values from the assessment phase to the treatment phase in all sets of data. The largest differences between the highest and lowest performance mode celerations were found before direct instruction, but differences in celeration values were still present for all four subjects after direct instruction. Learning in the low performance mode occurred at a faster rate during treatment than it had during the assessment phase, and thus the gap between high and low performance mode was lessened in terms of celeration values.

Generalizations Among Performance Modes

Each individual pattern of modal generalization was different for the three subjects with complete data sets. When compared with the rates from the first day of Phase A, measures from Phase A' showed none of the subjects improved in all four of the performance modes that were not targeted for direct instruction. Subject 1 improved in one other performance mode, Subject 2 improved in one other performance mode, and Subject 3 improved in three other performance modes.

Summary

The results of this investigation showed behavioral differences within subjects when subjects were required to perform math tasks using different performance modes. The results of a direct assessment of math performance yielded different celeration values for all six performance modes for all four subjects, indicating both intra- and interindividual differences in behavior. When subjects received direct math instruction in high and low performance modes, all math performances improved, but the rate of change differed within subjects and among subjects. Improved performances in the two performance modes targeted for instruction did not completely generalize to other performance mode conditions, and each subject made different generalizations. The discrepancies between high and low celeration values measured in the assessment phase were consistently greater than the discrepancies between celeration values measured in the treatment phase. When an individual was presented with a task at frustration level, a meaningful assessment of performance mode was confounded. Each subject's data revealed different patterns of behavior in terms of the see/say, see/write, see/touch, hear/say, hear/write, and hear/touch performance modes.

CHAPTER V

CONCLUSIONS

The results of this study have implications for classroom instruction and future research. The principal findings outlined in the previous chapter are discussed within chapter V in terms of behavioral differences within and among subjects, performance mode generalizations and classroom instruction, the role of training, task difficulty and performance mode, and measurement concerns. This chapter also contains an individualized instructional design for one subject that is intended as a model for application of performance mode data in a teaching plan. Finally, the chapter includes a brief proposal for programmatic research designed to answer additional questions about the relationships between performance mode and learning.

Discussion of Results

Throughout this discussion, the generalizability of the results is limited to elementary-aged children with learning problems in the area of mathematics, and the results may not be extended to other populations. Because the academic task presented to the subjects always involved basic math facts, the results may not be assumed to apply to other academic tasks, even for the four subjects who participated in the experiment.

Behavioral Differences Within and Among Subjects

The design of this study required subjects to respond to basic math fact problems using six different performance modes. Behavioral differences were noted when performances were compared within each subject and among the four subjects. Manipulation of performance mode did result in different rates of change in performance, different rates of correct responses per minute, and a different rates of incorrect responses per minute for each performance mode condition for each subject. Performance mode appears to have a complex relationship to the behavior of the four subjects involved in this study. The simple classifications of auditory learner, visual learner, and kinesthetic learner did not emerge, which supports Smith's (1971) contention that such categories are simplistic and artificial.

The results of this study suggest that some learners perform more efficiently using certain performance modes, and that learning may be accelerated if the proper performance modes are featured within instruction and testing for mastery. No single performance mode was found to be most efficient for all subjects, which is unlike Webster's (1980) finding that groups of math-disabled students performed best under see/say conditions. The discrepancy between the two research findings may be due to the larger number of modality combinations featured in this study and the examination of behavior on a single-subject basis. These findings point to a

possible need for individualized assessment of performance mode behavior and subsequent individualized instructional design.

Performance Mode Generalizations and Classroom Instruction

This experiment's principal finding about individual generalization patterns has potentially significant implications for some teachers and their students. The results of this study show that we may not assume direct math instruction using one performance mode results in improved rates on the same math task using a different performance mode. If this finding is applied to the classroom setting and math instruction for children with learning problems, some rather common instructional activities become suspect.

Special classes for children with learning problems often feature a tutorial arrangement for math instruction in which the student works with flashcards and practices see/say math facts. If the student in the special education classroom fails to generalize from see/say math facts to the see/write behavior required on the school's annual achievement test, then the special class training has not been entirely appropriate. Math instruction featuring a number of different performance modes may represent a waste of instructional time if the teacher does not first establish that the student is able to generalize from one performance mode to another. Assessment of individual generalization patterns across performance modes may provide a teacher with valuable input pertaining to each

student's instructional needs. Achievement in the mainstream of education requires careful planning for those students who experience learning problems. The generalizations made across performance mode behaviors may be a relevant variable within an educational plan for math instruction for a child with learning problems.

The Role of Training

Direct instruction. All presentations of direct instruction within this experiment were associated with increased rates of response on math problems. These results correspond with Koorland's (1977) finding that operant conditioning succeeded in changing subjects' modal preferences. Evidence points to positive effects for systematic training of performance mode behavior, even for those performance mode behaviors identified as low, or least proficient. The fact that celeration value discrepancies between high and low performance modes decreased in every instance when direct instruction was provided also points to the strong impact of direct instruction on performance mode behavior. For the purposes of this investigation, direct instruction in a target performance mode consisted of modeling using the performance mode, practice using the performance mode, feedback, measurement using the performance mode, charting, and reinforcement. These elements in combination consistently resulted in increased rates of the target behavior. Stephens, Hartman, and Lucas (1978) reported a large

body of research that also found direct, systematic instruction to result in increased academic gains. Direct instruction in the most efficient, prevalent, and/or functional performance modes for math tasks may increase the probability that students with learning problems will succeed in learning basic math facts.

Previous training. Previous training and experiences in performance mode behaviors almost certainly played a role in determining the results of the study. The novelty of responding to math problems by touching keys on a calculator probably contributed to the relatively high celeration values found in the see/touch and hear/touch performance modes. Subject 3's poor see/touch performance during assessment (the only instance of the touch response as a low performance mode) also improved rapidly with the addition of direct instruction in using see/touch. The high celeration values that occurred in see/touch and hear/touch performances indicate that the subjects succeeded at learning a new performance mode as well as learning math facts. Lack of previous training in using certain performance modes could account for both low fluency in initial trials and high rates of change across subsequent trials.

See/write was probably among the best trained performance modes for each subject prior to the experiment. This may account for the fact that see/write was not a high performance mode in terms of celeration values for any of the four subjects. Some see/write

performances were characterized by relatively small changes in rates across time, but these same performances were often among the most fluent. The optimal role of a performance mode assessment for an individual learner may be to detect if any of the more functional performance mode behaviors are not yet trained to proficiency.

Task Difficulty and Performance Mode

The math task selected for Subject 2 appeared to be at the frustration level, based on the low rate of correct responses per minute and the lack of increased rates after the addition of direct instruction. Presentation of fewer different facts did help increase the rate correct in the see/say condition, but the student continued to count on his fingers to calculate the subtraction facts. Subject 2's counting behavior may indicate he is in need of math instruction involving concrete objects. Several authors (Cawley, 1977; Goodstein, 1974; Underhill, Uprichard, & Heddens, 1980) have stated that some learners need experiences with sets of objects and/or illustrations of objects representing math operations before they will be successful at the abstract level that involves spoken or written numeric symbols. Presentation of a math task at an inappropriate level confounded a meaningful assessment of performance mode behavior.

The results of this study for Subject 2 point to another potential flaw in previous designs for modal preference research

with groups. In this study, the relationship between a task at frustration level for an individual and performance mode was quite logical: the individual did not do well across all six modality combinations. Assessment data for this individual did not predict performance during the treatment phase, whereas the high performance mode in the assessment phase for the other three subjects was also the high performance mode during the treatment phase.

Given a group design in which all subjects are given the same modality-based instruction and the same task for the dependent measure, it is possible that the subjects with learning problems will perform poorly across all experimental conditions. Thus, difficulty of task may confound an assessment of both inter- and intraindividual behavioral differences across different modalities. It is possible that previous group research has, by design, obscured any potential for detecting a modal preference in students with learning problems, and these students may be precisely the population for whom the concept of modal preference is most important.

Measurement Concerns

Celeration values for each performance mode condition led to convenient rankings and high and low performance mode distinctions, but the rankings did not always accurately reflect relationships depicted in the charted data. Trends in the rate of correct

responses and corresponding trends in the rate of errors combine to portray different types of learning patterns (Rose & Koorland, 1978). Range of rates and median rates from each set of data give an indication of fluency, which is also an important characteristic of behavior. High celeration values alone do not always characterize an efficient performance mode when other data are also analyzed. Alternative methods for calculating celeration values, such as the quarter-intersect technique (White & Haring, 1980), may improve upon the relationship between charted data and celeration values. The distinction between high and low performance mode should be based on a consideration of the following behavioral characteristics: fluency, trends in rate of correct responses, and trends in rate of errors. Attention to any one measure at the expense of the others omits critical information about intraindividual behavioral differences across performance modes.

A second concern about measurement of performance mode is the tendency to think of "modality" as a thing rather than as a classification of behavior. Performance mode is a descriptor of behavior; it is not intended to describe an entity within the individual. Gould (1981) carefully traced the fallacy of reification that has historically plagued many studies and measures of intelligence. Performance mode studies and measures must avoid a similar error, that of viewing modality as a unilinear, quantifiable trait.

Sample Individualized Instructional Design Based on Performance Mode Data

The following individualized design for instruction is based on the results of this experiment for Subject 3. The format for the design is Kemp's (1977) goal-oriented model for instructional design. Kemp's model was selected because of its utility for classroom teachers who must design instruction based on a predetermined curriculum and the attention given to learner characteristics within the model. In its graphic form (see Figure 6), the model is a circular figure that begins with goals, topics, and general purposes, and then proceeds to learner characteristics, learning objectives, subject content, pre-assessment, teaching/learning activities and resources, support services, and evaluation. The model incorporates the opportunity to revise one or all of the instructional components. Information outlined in Kemp's model also dovetails with many of the required portions of Individualized Educational Programs (IEPs), mandated by Public Law 94-142 for special education students.

The instructional design that follows is a scenario for the classroom and an example of systematic instructional design. The design represents a set of circumstances that is only one of the many possible instructional designs that may be developed for Subject 3 using the outcomes of the performance mode experiment. The worth of the design may be established through application of

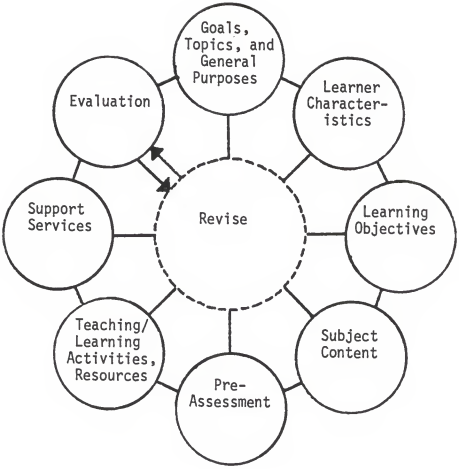


Figure 6. Kemp's model for goal-oriented instructional design, from Instructional Design (p. 9) by J. E. Kemp, 1977, Belmont, CA: Fearon Publishers. Copyright 1977 by Pitman Learning, Inc. Reprinted by permission.

the components described and a data-based evaluation of the student's performance on the tasks contained within the objectives.

Goals, Topics, and General Purposes

Subject 3 is entering the third grade, a year in which he will have to pass his state's academic skills test if he is to be promoted to the fourth grade. With one retention in his history, that alternative seems undesirable. Subject 3 has failed to qualify for special education classes after educational, psychological, and language assessments. The instruction designed for Subject 3 has the long-term goal of independent, accurate math calculation on the state assessment test taken at the end of the student's third grade year. The specific topics covered in this design are addition and subtraction facts, and tool skill rates for numbers. Because the statewide assessment test presents math tasks in the see/write performance mode, one general purpose is to provide instruction that results in Subject 3's mastery of see/write addition and subtraction basic math facts. A related general purpose is promotion within the public school system.

Learner Characteristics

The results of a direct assessment of performance mode behavior indicate that Subject 3's see/say performance was his most fluent one, and see/say was very accurate after direct instruction. This is an interesting finding in light of the language problems documented by speech and language professionals. The see/say

strength may reflect the extensive speech and language therapy Subject 3 has received, or it may indicate relative deficits in his use of other performance modes. Subject 3's data from the performance mode experiment show some high error rates, but the error rates decreased with direct instruction. After direct instruction in see/say and see/touch, increased rate of performance also occurred in see/write, hear/touch, and hear/write performance modes, but increased fluency did not generalize to the hear/say condition. Subject 3's least proficient performances during assessment were when he used the hand-held calculator.

Learning Objectives

Two types of learning objectives, enabling and terminal, are included in the list of specific objectives for Subject 3. The enabling objectives (EO) specify the prerequisite behaviors that must be mastered before the terminal objectives are accomplished. The enabling objectives for Subject 3 cover subsets of addition and subtraction basic facts using the see/say performance mode. Terminal objectives (TO) are designed to reflect the goals and general purposes stated previously within the design for instruction.

Performance aims within the learning objectives are stated as rates per minute, with the first value as rate correct and the second value as rate of errors (e.g., 60/2). According to Eaton (1978) "rate per minute is probably the most functional unit of

measurement in a classroom" (p. 173). Rate of correct and incorrect responses per minute yields the same information as does a percentage score, and it also gives an indication of fluency. A fluent performance, or a rapid and accurate performance, is thought to improve the probability of retention and generalization of the target skill (Haring & Schiefelbusch, 1976).

Proficiency rates stated for objectives involving calculations are based on the most recent measurement of Subject 3's tool skill rates for see/say numbers in sequence (66/0) and think/write digits zero through nine (45/1), and his highest rate recorded for see/say addition facts (44/0) and see/write addition facts (29/0). Each highest rate for calculation is approximately two-thirds of the corresponding tool skill rate, which will be considered proficiency for Subject 3. Terminal objectives are given for rate of calculating basic addition and subtraction facts, and for tool skill rates. The following learning objectives are designed for Subject 3:

EO1. Given a printed math probe with subtraction facts involving one-digit operands, Subject 3 will see/say differences at a rate of 45/2 numbers per minute,

EO2. Given a printed math probe with subtraction facts involving one-digit operands, Subject 3 will see/write differences at a rate of 30/2 digits per minute,

E03. Given a printed math probe with addition facts involving sums from zero through nine and subtraction facts with one-digit operands, Subject 3 will see/say sums and differences at a rate of 45/2 numbers per minute,

T01. Given a printed math probe with addition facts involving sums from zero through nine and subtraction facts with one-digit operands, Subject 3 will see/write sums and differences at a rate of 30/2 digits per minute,

T02. Given a piece of lined paper and a pencil, Subject 3 will think/write numbers zero through nine in sequence at a rate of 80/2 digits per minute,

T03. Given a printed probe of numbers in sequence, Subject 3 will see/say numbers at a rate of 100/2 numbers per minute,

T04. Given a hand-held calculator and the teacher says random numbers, Subject 3 will hear/touch keys at a rate of 60/2 digits per minute.

Subject Content

There are two parts of the subject content for Subject 3's individualized instructional design. First, basic addition facts involving sums zero through nine and basic subtraction facts with one-digit operands are the target of direct instruction initially using the subject's strongest performance mode (see/say) and then using the most practical performance mode in terms of school achievement (see/write). Second, because Subject 3 performs tool

skills at relatively low rates, direct instruction is also provided for the tool skills of reading numbers, writing numbers, and touching numbers on a calculator keyboard.

Pre-Assessment

Before direct instruction is begun for any of the objectives, baseline data is collected across three consecutive days. If the median rate of the baseline data is at or above the criterion rate specified in the objective, then a pre-assessment is conducted on the next objective's task. If the median rate is below criterion, then direct instruction is provided.

Teaching/Learning Activities and Resources

Based on previous rate measures, Subject 3 is performing subtraction facts with one-digit operands accurately, but the set of math facts is not yet at a proficient level. His rate of performing tool skills is also accurate, but below rates considered to be proficient. This type of performance indicates a need for drill and practice with feedback about rate and accuracy of performance (Haring & Eaton, 1978). Examples of drill and practice activities and resources include three different instructional arrangements: independent work, a small group activity, and a practice session for an entire class.

Independent practice. Subject 3 may practice basic math facts independently through the use of a self-correcting material (Mercer, Mercer, & Bott, in press). The self-correcting material is designed

to give the student feedback after practicing see/write basic math facts. Subject 3 is given a red acetate folder with his math facts probe inside. He uses a washable acetate marker and writes his responses on the acetate. After completing the probe, the student removes the sheet from the folder and checks the answers written in yellow on the probe with his answers written on the acetate folder. The red color of the folder hides the yellow writing on the probe during practice. The drill is also conducted using a tape recording with one-minute intervals of music and silence. Subject 3 uses a set of headphones to listen to the tape and practices one-minute samples of see/write math facts, after which he self-corrects the responses and notes number of correct and incorrect digits per minute.

Practice in a small group setting. One practice activity designed to promote fluency in the basic math facts is a board game for a small group. The rules for the game are as follows: each player has a math probe at an appropriate instructional level; the leader has duplicates of all players' math probes with answers written in; player one rolls a die; player one decides to either move the number of spaces indicated on the die, or to see/say (or see/write) from his or her probe for ten seconds and move one space for every correct answer; if the player chooses to work on the probe, the leader conducts a ten-second timing and determines the number of spaces the player may move; player two takes his or

her turn in the same manner, etc.; the winner is the first player to move around the board after every player has had an equal number of turns.

Practice in a large group setting. Direct instruction in the tool skills see/say numbers in sequence, think/write digits zero through nine, and hear/touch random numbers takes place in a large group of children, all of whom are performing tool skills below individually determined criteria. The brief instruction consists of three "sprints" of thirty seconds each during which the students all perform the tool skill as quickly as possible. The students are then instructed to evaluate their sprint in terms of correct and incorrect responses. After the sprints, a one-minute timing is taken as a daily measure of rate per minute. The see/write tool skill is performed and evaluated independently by each student; the see/say and hear/touch tool skills are performed and evaluated in pairs of students who trade turns at performing and recording.

Support Services

The teaching/learning activities for basic addition and subtraction facts take place in the regular classroom. The direct instruction in fluency of tool skill rates takes place in a Chapter I classroom on a daily basis. Subject 3 attends an afternoon tutoring program at the local university's College of Education, which provides additional practice in see/say and see/write addition and subtraction facts. An educational

diagnostician in the school district follows Subject 3's academic progress and provides periodic individual assessments of his academic achievement. Based on diagnostic data, the educational diagnostician makes recommendations to Subject 3's teachers and parents.

Evaluation

During the time an objective is the target of direct instruction, the specified behavior will be evaluated on a daily basis. Rates per minute will be recorded on a chart that features an aim star (White & Haring, 1980). The aim star indicates both the criterion rate and the date set as a goal for mastery of the objective. The student and the teacher will record daily rates and evaluate progress toward the aim. If fluency and accuracy are not increasing, one part of the instructional design should be revised and subsequent rates recorded. Changes in the instructional design are made one at a time to enable the teacher and learner to evaluate the effects of the change.

After all objectives are met, a direct assessment of see/say and see/write addition facts with sums 10 through 18 provides a starting point for the next cycle of individualized instructional design for Subject 3. In the next set of learning objectives, increased tool skill rates will result in increased performance aims for objectives involving math calculations. Subsequent performance aims will be set at approximately two-thirds of the student's current tool skill rates for related behaviors.

Proposal for Programmatic Research

One major conclusion of this study is that performance mode appears to be a complex variable in the learning environment; another conclusion is that we know relatively little about the relationship between performance mode featured in a task and individual behavior. The findings of this study suggest that for some students manipulation of performance mode may be related to efficiency of learning. This brief programmatic research proposal is in response to the complexity of performance mode and its potential importance for some learners. The purpose of the research will be to gain practical information for classroom teachers to use in designing individualized instruction for students, especially students who fail to achieve in school. The proposed program involves single subject research designs, group studies, and development of diagnostic tools.

Single Subject Studies

Replications of the present investigation. This exploratory study points to a need for long-range, single subject studies of performance mode behavior. Proposed replications of this study may result in more meaningful data if assessment and treatment phases are extended, allowing trends to develop more completely and revealing points at which rates begin to reach a ceiling for each subject. Each subject's ceiling rate, or highest rate demonstrated, for the different performance mode behaviors could guide future

selection of individualized performance aims. Allowing performances to reach proficiency before the treatment phase is concluded may influence the generalization patterns shown in the post-treatment phase.

Replications of this study with different populations, both handicapped and non-handicapped, could indicate if intraindividual behavioral differences across performance modes are limited to persons with learning problems, or are characteristic of a larger population. Replications of this study using the same subject(s) but changing the academic task could indicate if high and low performance mode patterns are a function of the task or if the individual patterns remain constant across tasks. If replications arrive at results similar to those of the present study, the generalizability of the principal findings could be extended to the variety of subject populations and academic tasks involved in the replications. If the results of replications refute or do not support the findings of the original study, then the generalizability may, in fact, be limited to particular populations and specific academic tasks.

Performance mode and instruction. Establishing the presence of intraindividual behavioral differences across performance modes raises the question of how to apply the information to designing appropriate instruction for the individual. Hunt (1981) emphasized the need for describing characteristics of student performance that

"are directly translatable into teacher actions" (p. 647). A study of the effects of implementing an instructional design based on performance mode data (such as the one described in the previous section) may indicate if manipulation of performance mode can improve academic performance. The possibility exists for an optimal sequence of performance modes for learning certain types of tasks. The proposed instructional design in the previous section sequenced "best" performance mode before instruction in the most functional performance mode, but at present this strategy is only a guess. The primary focus of research in this area would be efficiency of learning, an especially important concept for those students performing at levels below their current grade placement.

Individual behavior across several different tasks. Extensive single subject investigations may provide insights into the performance mode demands of different academic tasks. Research designs that require the same subject to perform a variety of academic tasks using different modality combinations may provide insights as to the durability of performance mode strengths and weaknesses across different types of tasks. This type of investigation could also be used to determine if the different modality combinations are appropriate for use with different academic tasks. The six performance mode combinations used in this study for a math task may not be equally appropriate for use with a spelling task, a map-reading task, or a language arts task.

Individual generalizations across performance modes. This study indicated that each subject made a unique set of generalizations among the six performance modes. Since there were two treatments, clearcut patterns of generalization were not established. Additional single subject studies are proposed to systematically investigate the generalizations that individuals make among a variety of performance modes. Research could be designed to determine if the patterns are consistent across time and task, and to develop instructional techniques that address any individual patterns of performance mode generalization established by the experiments.

Educational media and performance mode. Previous efforts to classify educational media as strictly visual or auditory in nature were not adequate classifications of most instructional materials (Gropper, 1976). Because performance mode is a more complex description of specific behaviors, educational media may be classified according to the performance modes required of students who work with the material. It is possible for several performance mode options to be featured within the same material. Research into the effects of systematic applications of different educational media featuring the different performance modes could provide practical information for the classroom teacher. Due to the unique patterns of performance mode behavior found among the subjects of this study, the single subject format is selected for research dealing with media and performance mode.

One outcome of this media research may be a format for a media classification system similar to the Annehurst Curriculum Classification System developed by Cornbleth (1981). Cornbleth's media classification system represents an attempt to systematically determine student/materials compatibility, but students are described with highly subjective terms such as sociability, motivation, and experience. Hickman and Anderson (1979) articulated the need for media research on the topic of the effectiveness of matching instructional materials to the special needs of students with learning problems. If matching students to materials according to performance mode characteristics proves successful, the most functional format for a classification system may be computerized filing systems accessed by a classroom teacher working with a microcomputer.

Group Studies

Performance modes and success in the mainstream. Although it seems plausible that academic work primarily requires students to look at stimuli and write responses, no data was found to support Webster's (1980) claim that see/write proficiency is required for success in the upper grades in school. Currently, there is not a data base that may be used to identify the performance modes most frequently used in classrooms. The proposed research program includes group research studies measuring time spent in the classroom using different performance modes, for both regular and

special education classes, at all grade levels. Performance mode use could be classified according to academic task, and the behaviors of successful and unsuccessful students could be analyzed. Research designs for this segment of the program are modeled after the classroom research reported by Ysseldyke and Algozzine (1983) in which a typical school day was analyzed in terms of time spent by students in different types of instructional activities. When the most prevalent and functional performance modes are identified, then students with learning problems may benefit from direct instruction in those performance modes required for success in the mainstream of education.

Proficiency rates for performance mode tool skills. Tool skills may be defined as those behaviors that are prerequisites for more complex academic skills. For example, before a student may be expected to see/touch answers to basic math fact problems at a high rate, the student must first be able to see/touch random numbers at a rate above that required for proficient calculation. Although some work has been done to establish proficiency rates for tool skill behaviors such as see/say letters, hear/write random numerals, and hear/say numbers (Haughton, 1980; Mercer, Mercer, & Evans, 1982), this area has not yet been thoroughly investigated. The use of a keyboard in making responses has not been adequately studied in terms of tool skill rates. Group studies could establish the tool skill rates of successful learners as guides for

proficiency levels in those tool skills for which there are not yet adequate standards.

Development of Diagnostic Instruments

If research to this point establishes that some learners do learn more efficiently when performance mode is manipulated in a systematic manner, then the next logical step will be the development of diagnostic tools that identify intraindividual differences in the use of performance modes. Critics of previous modal preference research have objected to the instruments used to measure modal preference on the basis of low reliabilities, arbitrary and artificial criteria used to establish modal preferences, and unequivalent tasks in different subtests of the same instrument (Austin & Donovan, 1978b; Derevensky, 1978; Larivee, 1981; Miller, 1979; Smith, 1971). Diagnostic tools designed to assess an individual's behaviors across performance modes must overcome the shortcomings of previous modal preference tests.

Study of performance mode behavior with novel tasks featuring nonsense stimuli, such as the experimental task used by Webster (1980), may establish standard test items that are not dependent on the learner's level of academic achievement; however, non-academic test items will not help the teacher determine what to teach the individual learner. Another possible assessment strategy is to combine criterion-referenced diagnostic procedures with performance mode variables, resulting in individualized learning objectives that

specify academic content and the corresponding appropriate performance mode. Continuous measurement and criterion-referenced tests to determine modal preference were suggested as an alternative to normed tests by Sabatino and Dorfman (1974). The use of continuous measures across several days can provide a more reliable measure of behavior than does a single measure on a standardized test (White & Haring, 1980). The end product of research with criterion-referenced diagnostic strategies may be an assessment process rather than a single assessment instrument.

Common Factors Throughout the Proposed Research Program

Throughout the proposed research program, primary attention would be given to variables that may come under the control of the classroom teacher. The pragmatic definition of performance mode may be operationalized into specific instructional practices and learner behaviors. Dependent variables would be observable behaviors that may be measured directly with high reliability, and generally the dependent variable will resemble an academic task. The proposed research is directed at improving the efficiency with which we teach and learn. Much work remains to be done.

Summary

The results of this study indicate that performance mode and learning appear to have a complex relationship that is unique for each subject. Broad classifications such as visual learner did not emerge, and results showed individual patterns of response that

could not be characterized as a single modal preference. Individual patterns of performance mode generalizations and the effectiveness of direct instruction may have implications for classroom instruction. The confounding influence of task difficulty may indicate another shortcoming of previous modal preference research that involved group designs. A sample individualized instructional design is outlined for one subject as an example of how performance mode data may be applied to the design of an educational plan. Finally, a proposal for a future programmatic research effort is described in terms of single subject studies, group studies, and development of diagnostic instruments.

APPENDIX A

DESCRIPTIONS OF SUBJECTS

Subject 1

Sex: Female

Age on first day of experiment: 11 years, 7 months

Grade placement on first day of experiment: 5.7

Public school program placement: Regular classroom and Specific Learning Disabilities Resource Room for reading and math

Reason for referral to the Multidisciplinary Diagnostic and Training Program: Learning problems

Diagnostic information:

Key Math Diagnostic Arithmetic Test: Total test grade score of 3.4

Wide Range Achievement Test, Spelling subtest: Grade level of 2.9, percentile rank of 3

Woodcock Reading Mastery Tests: Total test reading score of 2.8, percentile rank of 2

Wechsler Intelligence Scale for Children-Revised: Performance IQ of 88, verbal IQ of 61, full scale IQ of 77

Clinical Evaluation of Language Functions: Below criteria on 8 of 11 subtests

Peabody Picture Vocabulary Test (Form L): Age equivalent of 9 years, 0 months

Medical findings: Hearing within normal limits, abnormal EEG and possible seizures, currently no medications, history of ear infections

Subject 2

Sex: Male

Age on first day of experiment: 11 years, 8 months

Grade placement on first day of experiment: 4.7

Public school program placement: Regular classroom and Chapter I program prior to assignment to Diagnostic Classroom, full-time Specific Learning Disabilities classroom after exit from Diagnostic Classroom

Reason for referral to the Multidisciplinary Diagnostic and Training Program: Learning problems and behavior problems

Diagnostic information:

Key Math Diagnostic Arithmetic Test: Total test grade score of 3.7

Woodcock Reading Mastery Tests: Total test reading score of 2.5, percentile rank of 4

Kottmeyer Diagnostic Spelling Test: Approximate grade level of 1st grade

Stanford-Binet Intelligence Scale: IQ of 97

Vineland Social Maturity Scale: Social age of 10 years, 6 months, social quotient of 91

Clinical Evaluation of Language Functions: Slightly below 6th grade criteria on 2 of 11 subtests

Medical findings: Normal hearing, history of hydrocephalus (shunt in place)

Subject 3

Sex: Male

Age on first day of experiment: 8 years, 6 months

Grade placement on first day of experiment: 2.8

Public school program placement: Regular classroom, Chapter I, and speech therapy

Reason for referral to the Multidisciplinary Diagnostic and Training Program: Learning problems and language problems

Diagnostic information:

Key Math Diagnostic Arithmetic Test: Total test grade score of 1.7

Brigance Diagnostic Inventory of Basic Skills: Word recognition grade level of 1.3

Slosson Oral Reading Test: Grade equivalent of 0.8

Wechsler Intelligence Scale for Children-Revised: Verbal IQ of 87, performance IQ of 81, full scale IQ of 83

Test of Language Development-Primary: Language quotient of 79

Peabody Picture Vocabulary Test (Form L): Age equivalent of 7 years, 4 months, standard score equivalent of 88

Screening Test for Developmental Apraxia of Speech: 99% probability of belonging to the apraxia group

Medical findings: Normal hearing, frequent respiratory infections, occasional ear infections, 20/40 bilateral visual acuity, fine and gross motor coordination problems, possible mild cerebral palsy

Subject 4

Sex: Male

Age on first day of experiment: 12 years, 1 month

Grade placement on first day of experiment: 5.8

Public school program placement: Regular classroom

Reason for referral to the Multidisciplinary Diagnostic and Training Program: Learning problems, behavioral problems, medical problems

Diagnostic information:

Key Math Diagnostic Arithmetic Test: Total test grade score of 2.5

Woodcock Reading Mastery Tests: Total test reading score of 3.4, percentile rank of 7

Kottmeyer Diagnostic Spelling Test: Approximate grade level of 2nd grade

Brigance Diagnostic Inventory of Basic Skills: Word recognition grade level of 5.4

Wechsler Intelligence Scale for Children-Revised: Verbal IQ of 95, performance IQ of 78, full scale IQ of 85

Developmental Test of Visual Motor Integration: 7 years, 10 months

Wide Range Achievement Test: Reading grade rating of 5.9 and standard score of 92, spelling grade rating of 2.7 and standard score of 65, arithmetic grade rating of 2.1 and standard score of 60

Clinical Evaluation of Language Functions: Processing language age of 7 years, 0 months, production language age of 12 years, 0 months

Peabody Picture Vocabulary Test (Form L): Age equivalent of 9 years, 5 months, standard score equivalent of 81

Medical findings: Mild bilateral conductive hearing loss, frequent otitis media and perforation of eardrums, ear surgery, visual acuity ranging from 20/40 to 20/100 in both eyes and occasional double vision (exam prior to Diagnostic Classroom placement reported vision problems had resolved), fine and gross motor incoordination

APPENDIX B

SCRIPTS FOR INSTRUCTOR

The following scripts were used by the instructor to structure each session with each subject. The directions spoken to the subjects are contained within quotes, and the instructor's movements are contained within parentheses.

Phases A and A', Assessment and Post-Treatment

"In the next few minutes, you are going to work on (math operation selected for subject). You will answer problems in six different ways, and I will show you what to do before each one-minute timing. This is what I want you to do." (The instructor gives a ten second demonstration of the behavior required in a performance mode, and then administers a one-minute timing. Modeling behaviors are as follows:

1. See/say: Instructor has written probe on a table in front of her, uses index finger to point to each problem, and says the answers aloud,

2. See/write: Instructor has written probe covered with a sheet of acetate on a table in front of her, and uses a non-permanent acetate marker to write the answers,

3. See/touch: Instructor has a written probe on a table in front of her, uses index finger of non-preferred hand to point to

each problem, and uses index finger of preferred hand to touch the keys on a calculator keyboard to indicate the correct answers,

4. Hear/say: Instructor will play a cassette recording that presents math problems, and will say the answer aloud after hearing each problem,

5. Hear/write: Instructor will play a cassette recording that presents math problems, and will use a pencil and blank sheet of paper to write the answer after hearing each problem,

6. Hear/touch: Instructor will play a cassette recording that presents math problems, and will use a calculator keyboard to touch the keys corresponding to the answer to each problem.)

"Now it is your turn. Answer as you saw me do for one minute. Please begin." (Instructor times the subject for one minute, and records the rate of correct and incorrect responses.)

"Please stop. I like the way you worked so hard during the timing." (The rates are recorded on a chart after the assessment session, and are not shared with the student. The same process is repeated for the remaining five performance modes. The six probes are presented in a different order each day, and the starting point within the probes is changed each day.)

Phase B, Treatment

"For the next few minutes, we are going to work on (math operation selected for subject). This is what I want you to do: (Instructor will start at the beginning of the probe and model all

of the facts on the probe in the performance mode featured in the condition:

1. See/say: Instructor has written probe on a table in front of her, uses index finger to point to each problem, and says the answers aloud at a rate slightly faster than the subject's previous performance,

2. See/write: Instructor has written probe covered with a sheet of acetate on a table in front of her, and uses a non-permanent acetate marker to write the answers at a rate slightly faster than the subject's previous performance,

3. See/touch: Instructor has a written probe on a table in front of her, uses index finger of non-preferred hand to point to each problem, and uses index finger of preferred hand to touch the keys on a calculator keyboard to indicate the correct answers at a rate slightly faster than the subject's previous performance,

4. Hear/say: Instructor plays a cassette recording that presents problems at a rate slightly faster than the subject's previous performance, and will say the answer aloud after hearing each problem,

5. Hear/write: Instructor plays a cassette recording that presents problems at a rate slightly faster than the subject's previous performance, and uses a pencil and a blank sheet of paper to write the answer after hearing each problem,

6. Hear/touch: Instructor plays a cassette recording that presents problems at a rate slightly faster than the subject's previous performance, and uses a calculator keyboard to touch the keys corresponding to the answer to each problem.)

"Now it is your turn. Please practice all the problems." (The instructor points to or starts reading from a novel starting place on the probe.)

"Please begin." (The instructor records any problems to which the subjects responds incorrectly.)

"That was a good practice."

(If the subject committed any errors the instructor shows the subject the specific problems that were not correct.) "Here are some facts we need to work on because you did not say/hear/touch the correct answer(s). This is what I want you to do." (The instructor models correct responses in the appropriate performance mode with only those facts on which errors were committed.)

"Now it is your turn. Please practice these problems three times. Please begin."

If the subject did not commit errors during the first practice, or after practice on facts selected due to errors, the instructor says, "Now let's do some ten second sprints. See if you can move faster each time." (The instructor points to or begins reading at a novel starting point on the probe.)

"Please begin." (The instructor allows ten seconds to elapse,

and during the student's performance notes errors and number of correct movements.)

"Please stop. You made __ correct and __ errors. Your errors were on these problems. (Instructor shares notes with student.) Let's do another sprint." (Instructor repeats the sprints until the total instructional time reaches eight minutes.)

The above instruction is not to exceed eight minutes. At the end of eight minutes, the daily dependent measure is taken. The instructor says, "Now it is time for the last one-minute timing. If you say/write/touch more correct answers today than you did yesterday, you will earn a sticker." (Instructor points to or begins reading at a novel point on the probe.)

"Ready, please begin." (Instructor times the subject's performance for one minute and records the number of correct and incorrect responses.)

"Please stop. I like the way you tried to go faster. Today you made __ correct answers and __ errors. Let's put that on your chart." (The instructor records the rates on the subject's chart in view of the subject. If the student's rate correct was increased, the instructor gives the subject a sticker as a reward. If the subject's rate correct stayed the same or decreased from the previous day, no sticker is awarded. The instructor will tell the subject why the sticker is or is not awarded.)

After treatment is completed in the manner described above for one condition, the process is repeated for the other condition selected for Phase B. The sequence of presentation of each performance mode is alternated each day. Performance mode is kept consistent across modeling, practice, and measurement within each condition.

APPENDIX C

INTEROBSERVER AGREEMENT DATA

	Rate per minute						Agreement
Observation 1							
	H/T	S/S	S/W	S/T	H/S	H/W	
Instructor	25/0	36/0	23/0	23/0	12/0	25/0	1.00
Observer	25/0	36/0	23/0	23/0	12/0	25/0	
Observation 2							
	S/W	S/T					
Instructor	56/0	47/0					
Observer	56/0	47/0					
Observation 3							
	S/W	S/T					
Instructor	51/0	48/0					
Observer	51/0	48/0					

APPENDIX D

RATE DATA FOR ALL SUBJECTS

Subject 1

Day	Rates per minute (correct/error)					
	S/S	S/W	S/T	H/S	H/W	H/T
			Phase A			
1	26/0	32/0	36/0	10/1	23/0	24/0
2	23/1	21/3	40/0	11/0	21/1	26/0
3	24/1	38/8	44/0	12/0	22/0	29/1
4	35/1	38/0	43/1	13/2	23/1	26/4
5	31/1	23/1	36/0	12/1	24/2	31/5
			Phase B			
6		42/0 (baseline)				21/1
7		42/6 (baseline)				25/1
8		28/0				28/0
9		29/1				26/2
10		32/2				23/1
11		30/4				26/0
12		32/2				26/2
13		29/3				36/0
14		30/0				36/0
15		36/2				

Subject 1--continued

Day	Rates per minute (correct/error)					
	S/S	S/W	S/T	H/S	H/W	H/T
			Phase A'			
18	23/1	50/0	47/2	10/1	24/1	36/2

Subject 2

Day	Rates per minute (correct/error)					
	S/S	S/W	S/T	H/S	H/W	H/T
			Phase A			
1	10/1	11/0	6/0	10/0	6/1	7/0
2	13/0	13/1	9/2	8/0	7/2	5/1
3	(subject was absent)					
4	10/2	7/1	10/1	11/0	9/1	6/0
5	8/5	11/0	10/1	10/1	8/0	6/0
			Phase B			
6	12/0 (baseline)		10/1			
7	14/0 (baseline)		10/1			
8	8/2		7/0			
9	6/1		11/0			
10	33/0		11/0			
11	38/3		11/1			
12	35/3		13/0			
13	48/1		17/0			
14	49/0		13/1			
15	55/0					
16	51/0					
			Phase A'			
19	22/2	20/0	12/2	8/2	7/2	5/1

Subject 3

Day	Rates per minute (correct/error)					
	S/S	S/W	S/T	H/S	H/W	H/T
			Phase A			
1	5/0	13/0	6/0	13/0	19/0	4/1
2	8/3	12/2	9/6	16/0	22/0	7/6
3	17/9	23/1	6/10	20/0	25/0	7/8
4	22/11	25/1	9/15	18/0	24/0	11/8
5	35/2	28/0	5/10	19/1	28/0	8/10
			Phase B			
6	13/4		8/12 (baseline)			
7	22/2		10/8 (baseline)			
8	31/0		13/3			
9	(subject was absent)					
10	30/3		13/3			
11	35/0		14/4			
12	39/0		18/1			
13	34/1		21/0			
14	44/0		25/0			
15	39/0		27/1			
16			22/3			
17			24/2			
			Phase A'			
20	36/0	23/0	23/0	12/0	25/0	25/0

Subject 4

Day	Rates per minute (correct/error)					
	S/S	S/W	S/T	H/S	H/W	H/T
			Phase A			
1	23/2	36/1	22/0	14/2	17/1	14/0
2	26/1	40/0	34/0	21/0	17/2	18/0
3	32/0	40/0	42/0	19/0	22/0	17/1
4	40/0	47/0	34/0	23/0	26/0	17/0
5	37/0	41/0	40/0	23/0	26/0	19/0
			Phase B			
6	(baseline)	41/1	32/0			
7	(baseline)	42/0	34/0			
8		42/0	41/0			
9		51/0	41/0			
10		53/0	41/0			
11		56/0	47/0			
12		48/0	42/0			
13		51/0	48/0			

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BIOGRAPHICAL SKETCH

Deborah Ann Bott was born in Denver, Colorado, on March 23, 1954. She lived in the Denver area until 1969 when she moved with her family to Amarillo, Texas. Miss Bott graduated from Tascosa High School three years later.

In 1976, Miss Bott received her bachelor's degree in elementary education with an endorsement in language and learning disabilities from Texas Tech University in Lubbock, Texas. After graduation, Miss Bott traveled for one year as a Chapter Consultant for her sorority, Phi Mu.

Miss Bott's first teaching job was during the 1977 - 1978 school year. She worked with elementary-aged learning disabled students in a resource room setting in the Amarillo Independent School District. The following school year, Miss Bott moved to Tererro, New Mexico, where she was a teacher at the Brush Ranch School, a private boarding school for learning disabled adolescents. During the summers of 1978 and 1979, she taught in a summer program for learning disabled children at the Academic Development Service in Denver, Colorado.

In 1980, Miss Bott was given the position of Graduate Counselor for Alpha Nu Chapter and a scholarship from the Phi Mu Alpha Memorial Fund. She then moved to Gainesville, Florida, to attend graduate

school at the University of Florida. During 1980, Miss Bott completed her master's degree in special education and worked as a part-time special education teacher at Gainesville Academy.

Miss Bott's doctoral program included studies in the areas of learning disabilities, educational media, and instructional design. During her doctoral program, Miss Bott worked as a tutor for a college-aged learning disabled student, as a graduate assistant, as a teaching assistant, and as an educational diagnostician for the University of Florida's Multidisciplinary Diagnostic and Training Program. Miss Bott is interested in training special education teachers and in the development of instructional materials for learning disabled students.

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

Cecil D. Mercer, Chairman
Professor of Special Education

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

Catherine V. Morsink
Professor of Special Education

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as dissertation for the degree of Doctor of Philosophy.

Lee J. Mullally
Associate Professor of Instructional Leadership and Support

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

Stuart E. Schwartz
Associate Professor of Special Education

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

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This dissertation was submitted to the Graduate Faculty of the Department of Special Education in the College of Education and to the Graduate Council, and was accepted for partial fullfillment of the requirements of the degree of Doctor of Philosophy.

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